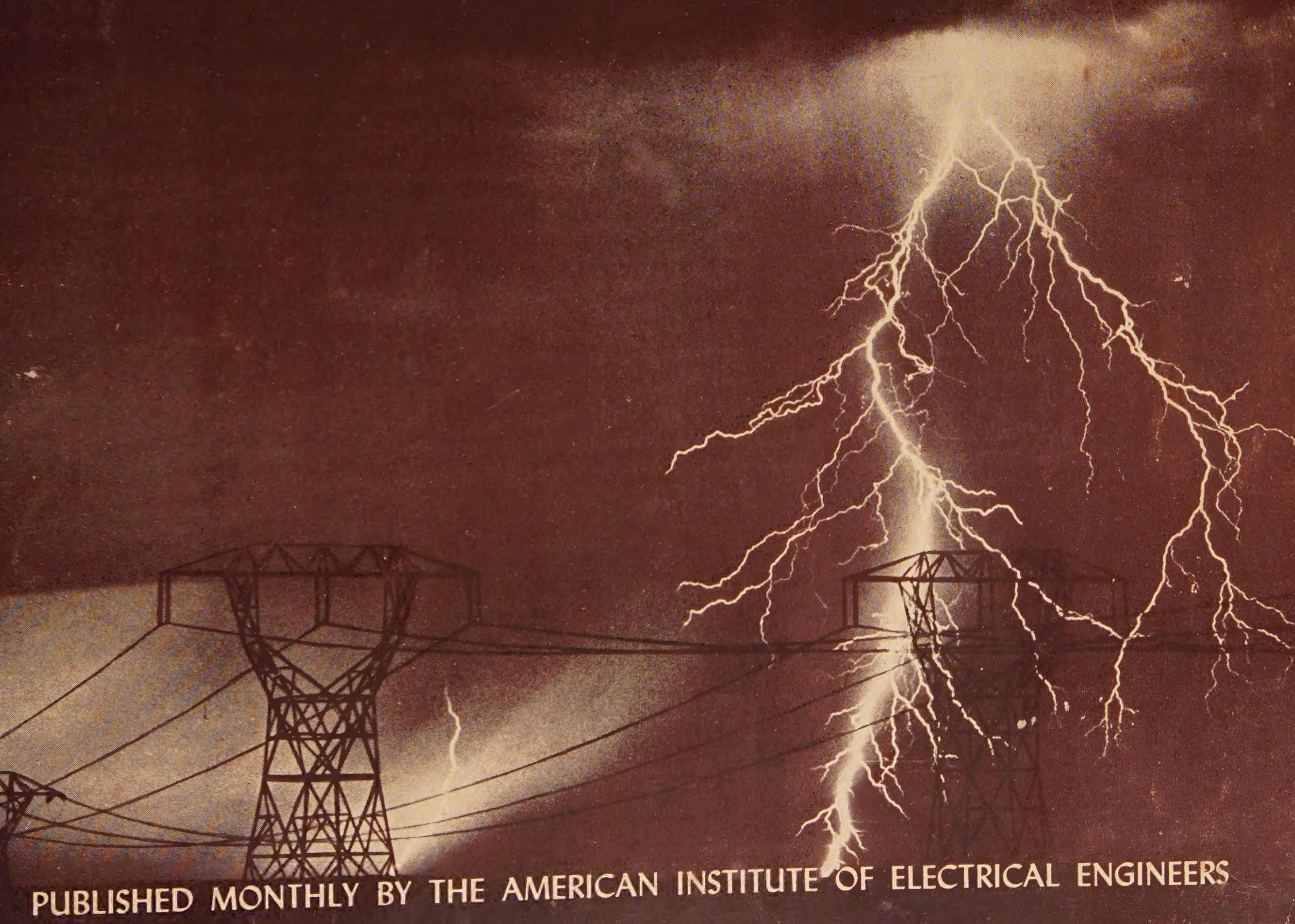
ELECTRICAL ENGINEERING

OCTOBER 1942



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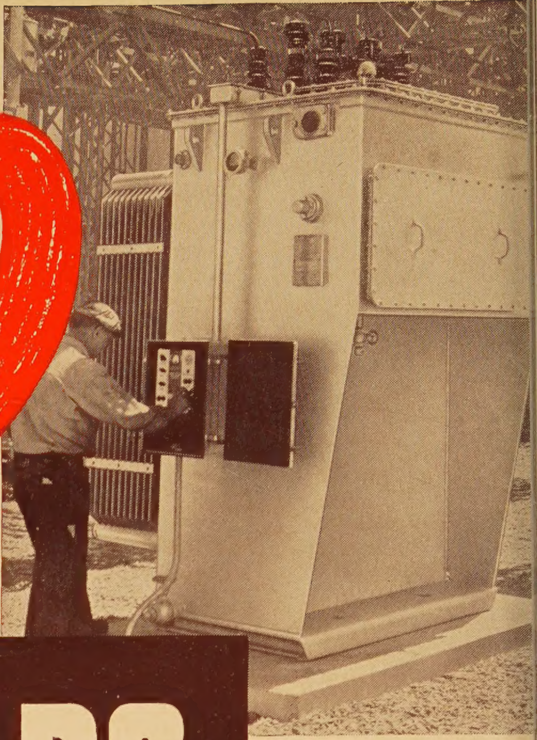

HELPING TO INCRI
production in war-busy i
trial plants, Allis-Chal
5/8% Step Regulators,
this 375 kva, 12,000
three-phase unit, are i
all over the country.

Improves Motor and Lamp Performance in New Armament Plant . . . Saves Thousands of Pounds of Copper and Vital Man-Hours for the Victory Effort . . . by Installing an Allis-Chalmers 5/8% Step Regulator!

A NEW armament plant was going up on the outskirts of a midwestern city. Power was to be supplied by an existing 5½ mile, 12,000 volt, Y-connected line already carrying 2100 kva. But the No. 0 copper wire was too small to handle the added 1500 kva load without excessive voltage drop at the end of the line.

One of the many solutions that occurred to the Planning Engineer was to put up heavier wire — 400,000 cm on the three conductors to keep voltage variation within 10%. But this would require 78,500 extra pounds of copper* and hundreds of man-hours.

Other possibilities included moving the substation, increasing the voltage, tying in with another line, or building a new line. But, weighing all factors, he decided to install a feeder voltage regulator to maintain uniformly high voltage.

The regulator required only a few hundred pounds of copper . . . a fraction of the man-hours to build. What's more, the regulator takes care of fluctuating source voltage . . . corrects for reactance as well as resistance drop . . . permits better motor and lamp performance.

And, when they actually bought the regulator, they selected a 375 kva, 12,000 volt, 3-phase Allis-Chalmers AFR, the regulator with *proved on-the-line performance.*

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*Weight of three 5½ mile lengths of 400,000 cm wire = 16.5 x 1220 x 5.28 = 106,300 lb of copper. Weight of salvaged No. 0 wire to be credited — 27,800 lb.

A 1521

REASONS WHY ENGINEERS CHOOSE ALLIS-CHALMERS 5/8% STEP REGULATORS!

1 **Closer Regulation!** 5/8% half-cycling steps plus "Feather-Touch Control" permit band width settings within ±5/8 of 1%.

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ELECTRICAL ENGINEERING

Registered U. S. Patent Office

OCTOBER
1942

The Cover: Lightning, one of the chief hazards to electric power lines, does not always cause outages, especially on modern lines. No outage resulted from these two strokes which occurred a few seconds apart near the Bonneville-Grand Coulee 230-kv line in the State of Washington. For further details see pages 541–2.

Photo courtesy Bonneville Power Administration

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HIGH LIGHTS • •

Electrochemical Installations. Electrical characteristics of various electrolytic cells for aluminum, magnesium, chlorine, copper, and zinc, and the requirements that such characteristics impose on the electric equipment are discussed from the viewpoint of the electrical engineer. A typical installation of conversion equipment for an electrolytic process plant is given, and the reasons for selecting the particular types of electric equipment and its physical and electrical arrangement are presented (*Transactions pages 733–41*).

Gas-Filled Cable. Improvement in gas-filled cable since 1938, covering the whole range of voltage ratings from 10 kv to 138 kv, is discussed. The divisions considered are: low-pressure gas-filled cable systems, 10 to 40 kv, operating at gas pressures from 10 to 15 pounds per square inch; medium-pressure systems, 40 to 69 kv, operating at gas pressures from 24 to 40 pounds per square inch; and high-pressure systems, 69 to 138 kv, operating at gas pressures from 150 to 200 pounds per square inch (*Transactions pages 719–26*).

Cellulose Insulation. Factors of major importance affecting the rate of mechanical deterioration of cellulose insulation are temperature applied and the presence of oxygen and moisture. In general, the mechanical life of the insulation is reduced by one half for each doubling in water content. Deterioration promoted by oxidation is most effective at temperatures below 120 degrees centigrade and is accelerated by the presence of moisture (*Transactions pages 742–9*).

Short-Circuit Analysis. An analysis is made of power-leg-to-ground and light-leg-to-ground short circuits, with formulas for line-to-line and three-phase faults, and of short circuits on the secondary circuits of single-phase transformers supplied from three-phase systems. The effects of resistance in limiting short-circuit currents and the voltage rise of the secondary neutral above ground potential caused by transformer failure and resistance to ground also are considered (*Transactions pages 757–64*).

Motor Insulation. In accelerated temperature and moisture tests on sample motors, insulation resistances and dissipation factors appear to have more consistency and significance than they have been given credit for. Based on limited data, motor insulation appears to be more vulnerable to adverse moisture conditions than to moderately excessive temperatures (*Transactions pages 707–12*).

Static Electricity as an Incendiary. The origin of a number of "mysterious" fires and explosions occurring in connection with gasoline and other inflammable materials has been traced to the unsuspected presence of static electricity, by investigators who knew what to look for. Case histories of two such gasoline fires have been presented in detail (*pages 501–8*).

The Electromagnetic Field. In a review of the development of electromagnetic theory, the widely taught concept of moving lines of force in a magnetic field, when applied to open circuits, is criticized by a well-known physicist as "wrong in theory and disproved by experiment" (*pages 511–16*).

Bimetal-Type Wattmeter. Experiments with a bimetal-type thermal wattmeter indicate that high torque is obtainable with this meter by taking advantage of the "internally heated" principle which offers maximum heat-transfer efficiency and gives a time-of-response characteristic much closer to the ideal simple exponential than has been attained in commercial meters in the past (*Transactions pages 764–70*).

Amplidyne Generator. The steady-state theory of the amplidyne generator is substantiated by comparison of experimental data obtained on a test machine with results calculated from the machine constants. Effects of brush losses, commutation, and over- and undercompensation on the operation of the generator are explained (*Transactions pages 750–6*).

Locomotive Control. Application of a resistor transition scheme to a modern a-c locomotive produced improvement in the acceleration of the locomotive, reduction in arcing duty on the tap switches as shown by almost complete lack of any arc noise, and much smoother operation of the locomotive when notching (*Transactions pages 727–32*).

Need for International Understanding. An engineer of wide foreign experience cites the simple and controllable circumstances that lead often to international misunderstandings. He points out that stable international relationships can grow only out of the intelligence and conscious effort of the individual (*pages 525–6*).

Vocational Education. Some of the factors affecting future trends in vocational education in the United States are analyzed by the Connecticut state commissioner of education, who emphasizes the need of new attitudes if the overacademic tendency of our schools is to be balanced by worthwhile vocational training (*pages 520–3*).

Conservation Through Good Engineering. A wartime policy aimed at the conservation of materials by educating users of electric apparatus to apply equipment more closely and lay out systems with the least possible use of strategic materials has been established by the AIEE technical program committee (*page 524*).

National Salvage Campaign. A salvage program in every plant is the theme of the WPB campaign to collect throughout the United States idle materials which are available for scrap and which can be put into the production of vital war goods (*page 535*).

Rural Electrification. The steady progress in the application of electricity to agriculture indicates that a new branch of engineering—electroagricultural engineering—and a new industry to supply necessary equipment are emerging gradually (*pages 517–20*).

Calculation of Fault Currents. A simplified procedure for calculating short-circuit currents, which has had a year's trial use with satisfactory results, is now recommended by an AIEE committee for general use (*pages 509–11*).

Ignitron rectifiers. More than 2,000,000 kw of ignitron rectifier units have been purchased by the electrochemical industry. Primary installations for these large power concentrations are described (*Transactions pages 713–18*).

Pacific Coast Meeting. For those unable to attend the 27th AIEE Pacific Coast convention, September 9–11, an eyewitness account appears in this issue (*pages 524–5*).

Coming Soon. Among special articles and technical papers currently in preparation for early publication in *Electrical Engineering* are: an article describing an electronic circuit for determining power-angle oscillations of synchronous motors during the period of hunting by M. J. DeLerno (Enrolled Student) and R. T. Basnett (A'42); an article on carrier-current relaying and communication on the TVA system by M. S. Merritt (A'38) and T. D. Talmage (M'40); an article relating to national efficiency during wartime by G. A. Gaherty; a report of the AIEE Engineering Foundation research project pertaining to the stability of impregnated-paper insulation; two papers on circuit-breaker performance, one on the problem of switching large capacitor banks by T. W. Schroeder (A'37), E. W. Boehne (M'37), and J. W. Butler (M'38) and the other discussing the response of high-voltage circuit breakers to transient recovery voltages of very high frequency, by R. C. Van Sickle (M'37); a paper on the relative expense for service restoration with different types of overcurrent protection for distribution circuits, by G. F. Lincks (A'37) and C. R. Craig, and a paper by Charles E. De Leuw, describing the first unit of the $64,000,000 Chicago Subway, which is expected to be completed and in operation early in 1943.

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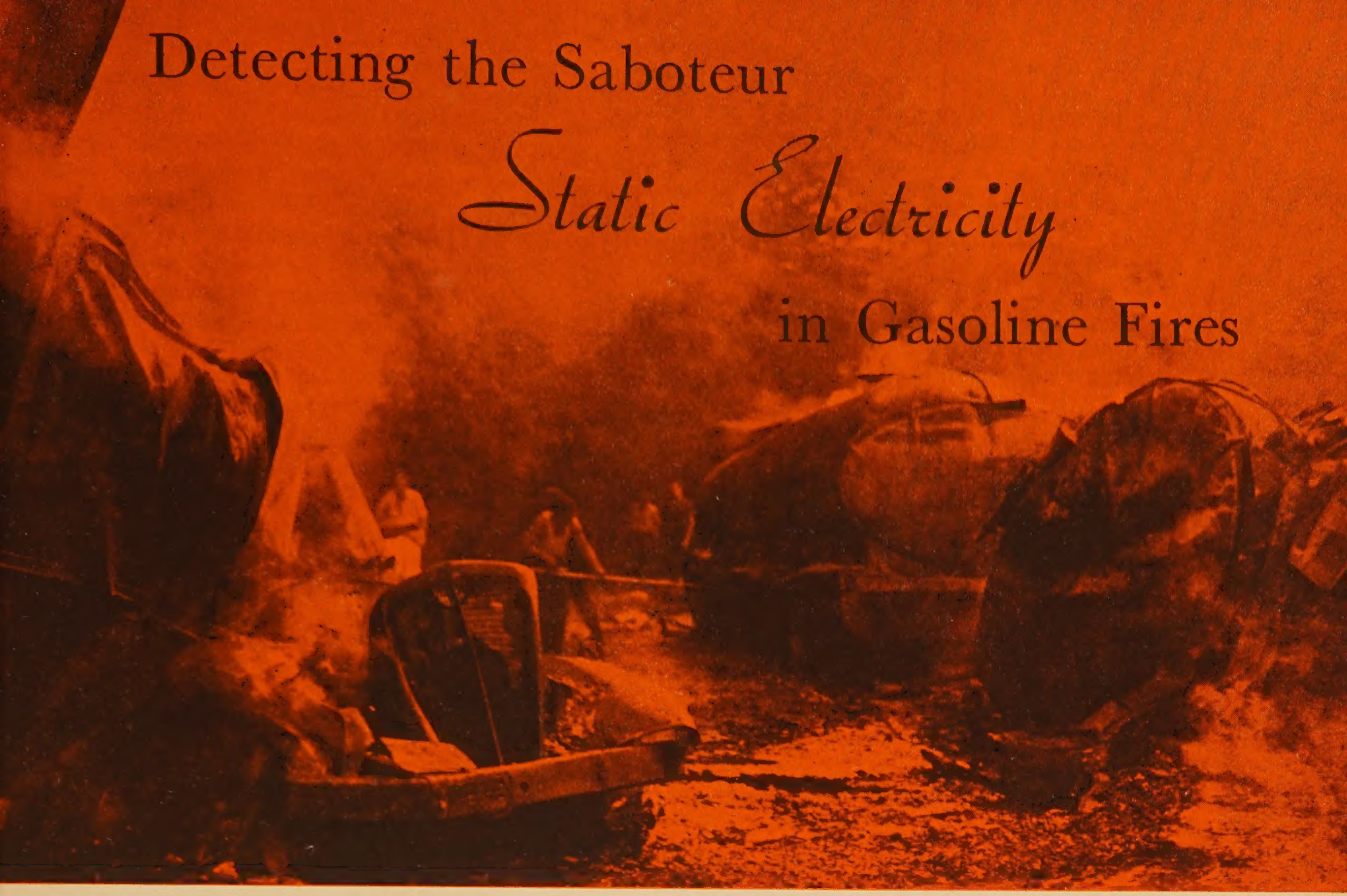
Detecting the Saboteur Static Electricity in Gasoline Fires



ROBIN BEACH
FELLOW AIEE

Dreadnaughts of the highway pictured above were victims of a fire caused by a tiny electrostatic spark. The trailer gasoline-tank truck (right) exploded and the huge motor carrier (left) was completely destroyed. The violation of safety practices in the handling of gasoline and other inflammable products also leads frequently to economic waste and loss of life. This article outlines the procedure followed in two cases for detecting the origin of electrostatic sparks and for correcting the hazardous conditions that caused them.

STATIC ELECTRICITY, as encountered in industry, may well be likened to a subtle foe, the saboteur, whose sinister purpose is not suspected until too late, after the harmful blow is struck. When the facts become known, it is an amazing revelation to learn how extensively the tenacles of this destructive agent, static electricity, reach out in their depredations upon industrial production. In some industries static electricity is ever active in starting fires or causing explosions, as for example in the manufacture of cereals, the proofing of fabrics, the making of explosives, and the handling of petroleum distillates and other highly inflammable products. In other phases of industry, it leads to the curtailment of production, as in the clogging of printing presses and the destruction of paper during manufacturing processes. The textile industry feels its presence through the development of imperfections of products, wherein the repulsion of electrified fibers of thread blurs the definition of patterns. In the photographic industry, static electricity causes the halation, marking, or puncturing of films. These are but a few of the many industries that are harassed by its destructive attacks.

In the petroleum industry, among others, fires and explosions have occurred, wherein the probable causes have not been determined, although thorough investigations perhaps would have revealed these catastrophes as being of static electrical origin. In all these industries where highly inflammable or explosive products are manufactured, transported, or used, fires and explosions occur

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During the technical investigations and the laboratory tests in connection with this article and while it was in the process of preparation, many individuals generously assisted the author. He wishes to acknowledge in particular the co-operation of the following: Edward F. McCrossin, McCrossin and Company, Engineers, New York, N. Y.; N. D. C. Pitcher, vice-president, American Casualty Company, Philadelphia, Pa.; Edwin W. Higgins, attorney, Norwich, Conn.; Lucius F. Robinson, Jr., attorney, Hartford, Conn.; and W. J. O'Donnell, Preferred Accident Insurance Company of New York, N. Y.

from time to time for which no known causes are attributed. Writing "unsolved" as the finis to these unfortunate episodes merely gives recorded expression to the inability of the investigator, first, to recognize among the various elements of evidence a trend toward a probable hypothesis of the source of ignition, and second, to reconstruct from a mass of gathered information a rational pattern of primary facts and complementary data that should strongly support a deduced "competent producing cause" of the fire or explosion.

THE INVESTIGATOR: TRAINING AND EXPERIENCE

Experience in exploring the scenes of disaster, ability to make accurate and critical examinations of debris as well as to formulate logical conclusions from such findings, and facility in gathering a full complement of facts both from personal observations and from interested individuals—all are characteristic attributes which distinguish the successful investigator. In addition he must possess an extensive background of scientific knowledge, natural explorative capabilities, and an adeptness in applying simple experimental confirmations of propounded hypotheses, in order to serve effectively in establishing "causes" from observed "effects." In order to be able to trace every hidden line of suspicion involving static electricity as a likely cause of the ignition where fires or explosions have occurred to inflammable products, and to gather and identify all such indicative clues and evidence as found at the scene, he should certainly have specific knowledge of the generation and behavior of static electricity.

These detectivelike services offer to the investigator with imagination and resourcefulness attractive opportunities for interesting, explorative, and critical study. Such investigations savor somewhat of the technique of crime detection, with static electricity characterized as the suspected saboteur. What evidence is obtained consists, by nature, mostly of the circumstantial type. The laboratory and the scientific approach are indispensable in developing a chain of incontrovertible evidence against this wily saboteur.

As information—either facts from observation or experimental data—becomes available during the investigation of a fire or explosion, an excellent procedure in attempting to determine the most probable cause of ignition is first to list every conceivable possibility that has any support in fact for the case under consideration. Then, with all known facts at hand, the investigator should devote a critical study to each of the proposed possibilities, eliminating those which possess little or no supporting proof. Through further speculation, study, and synthesis of facts and data, sometimes a supporting, although at first perhaps a nebulous, pattern of related findings leads to the substantiation of one, or even two, of the suggested causes.

In some instances, inexperienced consideration of the assembled facts has led to misconceptions or to erroneous interpretations from which no tenable theory for the origin of the fire could be derived. In such dubious and perplexing cases, the facilities of the experienced and qualified investigator become of inestimable value. Quite probably, in his study of other disasters, he has discovered that some fires and explosions, the causes of which likewise were at first shrouded in uncertainties, seemingly occurred under similar, marked, and perhaps attention-arresting, patterns of unusual circumstances or of striking peculiarities. Experience with such exceptional cases provides the investigator with a wealth of knowledge concerning the vagaries of fire origins, which aids him immeasurably on critical occasions in marshalling the many vague and weak clues to his problem into a strong and irrefutable chain of evidence to support his claim of the most probable cause of the fire.

Two interesting examples of fires traced to static electric origins are cited herein and explained, to illustrate the investigator's problems, his explorations for the facts, and his recourse to science for supporting evidence, in attempting to ascertain the probable causes for the ignition of inflammable gasoline vapor–air mixtures wherefrom the burning resulted in extensive secondary damages. Both examples relate to fires that were started during the refilling of underground gasoline-storage tanks at garages. The first case of fire occurred at a privately owned filling station on an estate, and the second relates to a fire at a commercial filling station on a large garage property.

THE FIRST CASE

An underground 550-gallon gasoline-storage tank, which was located at the side of and near the entrance to a garage on an estate, was being filled from a tank truck of conventional type. The hand-operated pump for the storage tank was located at the end of the tank nearest the garage door. About eight feet away at the remote end of the tank, a $1^1/_2$-inch vent pipe, which extended above the ground to a height of about four feet, was capped with a weather-protective hood. Between these, at about the middle of the tank, a conventional $2^1/_4$-inch fill pipe was connected into the underground tank at its lower end and terminated at its upper end in the fill receptacle with its screw cap and cover plate, which extended a little above the level of the ground.

About a minute and a half after the flow of gasoline from the truck into the storage tank started, fire was observed to burst out of the vent pipe and the fill hole of the storage tank. The driver, who at the time was at the cab end of the truck, immediately shut off the valve at the rear end of the truck, started the engine, and quickly drove out of range of the fire. Subsequently the garage and the adjoining buildings caught on fire, and considerable damage resulted.

Many months later, the author was called upon to investigate the case for the purpose of trying to determine the initiating cause of the fire. He then learned that other investigators who had worked on the problem had given it up as an "inexplicable mystery." In trying to obtain all the available and pertinent information, he first questioned many people who had various interests in the matter, including the personnel employed on the estate and by the oil company. Then, too, he conducted an examination of the gasoline tank which he partly excavated, and also made certain electrical tests at the premises. Later, valuable data were obtained from various supplementary experiments and tests.

From all these sources, applicable information was gradually disclosed which led to the formulation of a probable solution to the problem of how the fire started. The essential facts and data are summarized briefly in the following paragraphs:

1. The local weather record for several days prior to and at the date of the fire showed an extremely dry, hot period.

2. It was stated that, at the time of the disaster, during the forenoon, no fires of any kind, such as burning gas jets, stove fires, lighted lanterns or candles, or bonfires, had existed within several hundred feet of the storage tank and garage.

3. Also the investigators were told that no electric apparatus, such as electrically driven pumps, compressors, and other commonly used domestic equipment, including electric lights or heaters, were either in operation or being started anywhere near the filling station at the time just prior to the outbreak of the fire.

4. One of the workmen at the estate declared that he was in full view of and near the filling station at the moment the fire was observed, and he corroborated the truck driver's statements that at the time the driver was at the cab of the truck preparing the sales ticket, that he was not smoking or lighting a match, that the engine of the truck was not running, and that no pumps or other gadgets were being operated from the storage battery on the truck.

5. The truck driver was reported by the oil company to be a careful operator, to have an excellent service record, and to enjoy a reputation for honesty and reliability.

6. The truck driver further stated that, in conformity with his company's regulations and practices, after he had backed the truck to within about ten feet of the underground tank, he first connected the ground wire from the truck to a grounding clip on the vent pipe of the storage tank, and then placed the hose nozzle in the fill pipe of the tank, afterwards connecting the hose to the outlet valve at the rear of the tank truck. When all was in readiness, he opened the valve which permitted the flow of gasoline. He then went forward to the cab to prepare the sales slip for the delivery of gasoline.

7. The gasoline flowed through the hose by gravity from the truck into the storage tank. The standard fill hose on this truck permitted a rate of flow of about 50 gallons per minute, and the meter later indicated that a total of about 75 gallons of gasoline had been discharged by the time the fire started. This finding was supported by subsequent tests in confirming the fact that about a minute and a half was actually the time required for the discharge of the registered amount of gasoline.

8. After the fire, investigators found a part of the ground wire still connected to the vent pipe, where it had evidently been broken as the truck was hastily driven away—a fact which supported the driver's statement that he made the connection in conformity with the company's code of safety regulations.

9. The driveway where the truck stood was composed of a foundation of crushed rock with a surfacing of blue stone. Its electric resistance was measured between a thoroughly prepared ground and a metal plate which was fitted into good contact with the roadway surface—the plate representing the combined area of roadway contact by the truck tires. This resistance was found to be of a very high order—measuring "infinity" on the 100-megohm megger, this being the only one available at the time of the tests. Later tests on similar roadbeds indicated that this resistance was probably of the order of 10^{11} or 10^{12} ohms.

10. The shoes which the driver had worn at the time of the fire were also measured to determine their resistance from the bare feet through the leather soles to an artificial ground consisting of a thick layer of pulp newspaper, thoroughly soaked in brine. The resistance from the body to this artificial ground, through both shoes in parallel, was found by the megger to be about 5 megohms, or approximately 10 megohms per shoe.

11. The 550-gallon storage tank had been purchased, secondhand, from a jobber, who had painted the tank, the vent pipe, the fill pipe, and the fittings with several coats of heavy black paint. A sample of the paint, taken from the tank and chemically analyzed, was found to be composed of a base of titanium oxide and a binder of asphalt—both of which substances possess excellent insulating and dielectric properties. In consequence of this, the metal of the tank was well insulated from the surrounding ground. Of course it should have been thoroughly grounded, but unfortunately little if any thought is in general given to the matter at the time of installing tanks. As installed in this case, the metal of the tank therefore constituted one plate of a capacitor, with the ground as the other plate, and the intervening paint served as the dielectric.

12. During the excavation for the original installation of the tank, large rocks had been encountered. Consequently, the tank, instead of being buried to the recommended depth of at least 24 inches from its top surface, in order to insure the presence of moist earth around it for intended grounding purposes, actually was covered by less than 6 inches of soil. An exploratory excavation revealed, in addition, that the entire bottom of the tank and parts of its sloping sides were practically free from contact with the earth and that it was essentially resting upon the large rocks as a foundation. At the time of inspection an attempt to measure the capacitance of the metal of the tank to ground was not successful, as the subsoil was thoroughly wet from a long rainy spell; also parts of the tank had been disturbed since the fire, and the dielectric resistance at this time was only a few ohms. However, from the dimensions of the tank, and by taking into consideration the cavitation conditions of the soil, a very rough calculation showed its capacitance to be of the order of 500 micromicrofarads, that is, 500×10^{-12} farad.

A SOLUTION

Working on the rational assumption that the start of the fire was not of common origin, as each of such possible sources seemed reasonably to have been eliminated, attention was focused upon the possibilities of static electricity as the offending cause. Since almost no quantitative data were then known concerning the magnitude of potentials and charges developed on the bodies of rubber-tired vehicles as they ran along the highways, or concerning the conditions under which these static electric charges were retained on vehicles when they stopped, a special research study was devoted to the problem. The results of this investigation were reported by the author in the May 1941 issue of *Electrical Engineering*, under the title "Static Electricity on Rubber-Tired Vehicles."

Tank trucks, like the one here concerned, were commonly found to generate, between their bodies and ground, 15,000 to 25,000 or more volts, while running along dry highways. Under favorable conditions these voltages sometimes persisted for hours after the vehicles came to rest. When the tires and the roadway were dry the electric charges on the vehicles were impounded there by the excellent insulating properties of the rubber tires and the roadway materials. Also measurements of the electric capacitance of the metallic structures of tank trucks to ground were taken, and the capacitance values found to be of the order of 700 to 1,200 micromicrofarads.

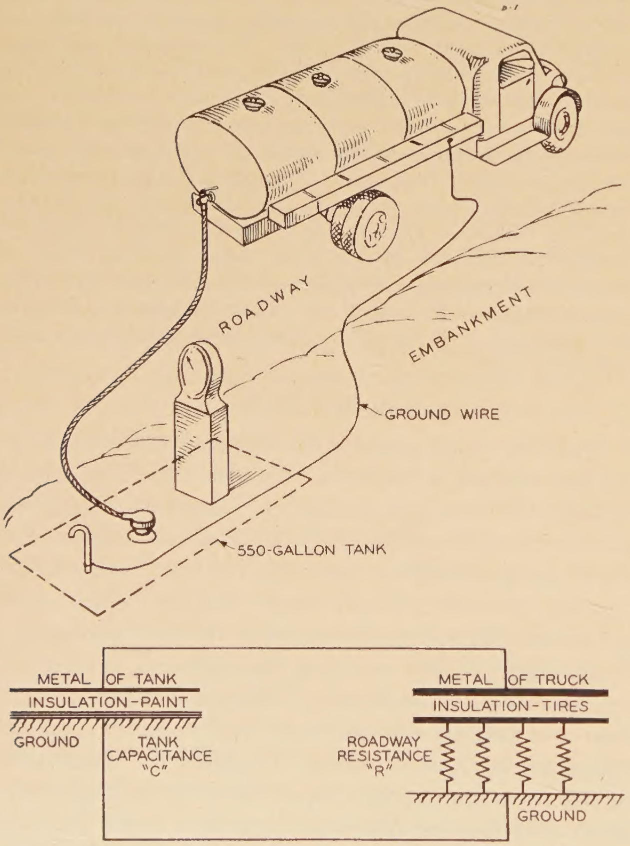

Figure 1. The approximate equivalent electric circuit represents the condition shown above, wherein the insulated underground gasoline storage tank is being charged from the electrified tank truck

Let it be assumed that the tank truck under consideration retained a charge at several thousand volts and that it was electrically connected to the underground storage tank both by the ground wire and by the fabric-enmeshed wires contained within the fill hose. Since the storage tank and its vent and fill pipes were all insulated from ground by the layers of paint, electric charges flowed from the truck body to the metal of the underground tank, as a capacitor, at a rate determined by the resistance in this completed electric circuit. The electrical conditions existing here are represented schematically by the conventional equivalent circuit diagram of Figure 1. As shown in this figure, the electric resistance from the tire treads through the roadway material to the earth surrounding the tank was of the order of possibly 100,000 megohms. Therefore, the electric charge from the tank truck would be conveyed to the storage tank in a slow logarithmic growth according to the equation

$$q = Q_F - Q_F e^{-\frac{\;}{RC}}$$

where q represents the charge on the tank at any time t; Q_F symbolizes the maximum charge that the tank can acquire for a given value of voltage; R represents in ohms the resistance of the electric circuit between the truck, as a charged capacitor, and the storage tank as a charge-receiving capacitor—an enormous value of resistance which is numerically about equal to that through the roadway from the tire-treads to electric ground; C indicates the value in farads of the capacitance of the storage tank; and e stands for the base of the Napierian system of logarithms, the approximate value of which is 2.718.

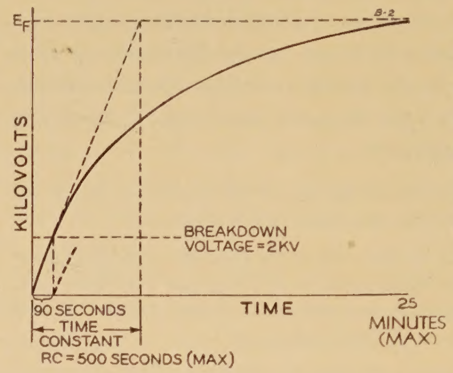

Figure 2. Approximate growth of voltage across the insulated underground gasoline storage tank, as a capacitor, while it is being charged from the electrified tank truck

The growth of voltage across the capacitance, as formed by the insulated storage tank and ground, also increases in a like manner to the charge. This is true because the voltage increases in exact proportion with the increasing charge in the capacitor, as shown by the basic relationship: volts = coulombs/farads. The graph of this growth of voltage is shown in Figure 2.

During the time that the voltage was building up on the storage tank, gasoline was being discharged from the truck into the tank. A volume of vapor equal to the volume of in-flowing gasoline was being simultaneously expelled through the vent pipe. The expelled vapor, being nearly four times heavier than air, flowed directly down to ground, covering the area above the tank and adjacent to it. Some of this vapor mixture with air naturally seeped into the ground around the tank through the interstices of the soil. Had the vent pipe been properly installed to a height of ten feet above the roof of the adjacent garage, the probability of the gasoline vapor–air mixture maintaining its inflammability through the intervening distance to the tank would have been practically nil.

Additional measurements showed that the paint on the tank was in a somewhat deteriorated condition, and that it would probably be punctured under the stress of

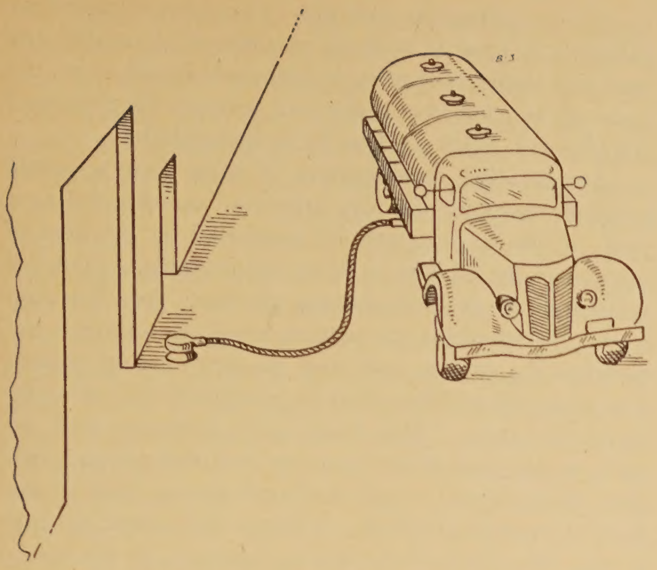

Figure 3. **From the diagram, several violations of recommended safety codes may be observed**

1. *The fill pipe should be located not less than five feet from the garage structure*
2. *The engine of the truck, which should not have been running, is within six feet of the combined fill and vent pipe*
3. *A separate vent pipe, equal in cross section to the fill pipe, should extend ten feet above the highest point of the adjacent garage*

approximately 2,000 volts. When this took place, a spark would be permitted to pass through the paint and to discharge the storage tank. Upon the occurrence of such a spark in this case, the gasoline vapor–air mixture, if within the range of inflammability, would ignite, and the flame propagation would instantly travel back to the sources of the vapor issuing from the tank—one being the near-by vent pipe and the other the fill pipe.

Furthermore, as soon as one spark occurred and the storage tank was electrically discharged, the cycle of recharging it and of restoring the voltage across the tank until another discharge spark took place could continue until the truck body had finally dissipated its entire electrification.

THE SECOND CASE

In the second illustrative case a series of circumstances occurred that was remarkably similar in some respects to those cited in the first example. Here an underground gasoline tank at a large filling station was rated at the same storage capacity as the other, 550 gallons, but this tank was not provided with the customary type of vent pipe. The approved type of vent for this size of storage tank as specified by the National Board of Fire Underwriters, is a $1^{1}/_{2}$-inch pipe "extended to a location where the vapors discharging from the vent will be readily diffused without danger of ignition." The regulations for the City of New York require a vent pipe of the same diameter as the fill pipe, and if a building is within 30 feet of the tank, the vent pipe must extend up the side of the building to a height of 10 feet above the roof. Instead of having a vent of an approved type, this tank was equipped with a very old, unusual, and dangerous combination of fill pipe and vent pipe formed into a single unit. The arrangement of the parts of this combined unit, including the inserted hoze nozzle, is shown in the cross-sectional sketch of Figure 3.

From this sketch, it can be observed that a substantial outer galvanized-steel pipe was connected at its lower end into the storage tank, while its upper end supported the fill head, which protruded about 6 inches above the ground level. The fill pipe was contained coaxially within this outer casing, the upper end consisting of a $2^{1}/_{2}$-inch length of 2-inch brass tube which was secured to and supported from the fill head. The remainder of the fill pipe was 20 gauge zinc of $2^{7}/_{32}$-inch inside diameter that was sweated over the upper 2-inch brass section. The lower end of the fill pipe extended about 12 inches down into the storage tank. The space between the inner and outer pipes, which consisted of only $^{1}/_{32}$-inch radial clearance, was intended to serve as the vent for the tank. However, this permitted only a very small vent area of 0.22 square inch, whereas the fill pipe had a cross-sectional area of 3.15 square inches. Six $^{1}/_{4}$-inch holes, which extended through the steel plate in the top of the fill head, connected with the enlarged vent space between the brass fill pipe and the coupling at the top of the outer support pipe. While the tank was being filled, the displaced gasoline vapor was expelled, in part, through the vent space provided for this purpose between the inner and outer pipes and through the small holes into the atmosphere above the fill pipe, but because of the gross inadequacy of this venting area, much of the vapor was forced out through the fill pipe.

During the operation of filling the tank, the nozzle of the fill hose, which had an outside diameter of $1^{3}/_{4}$ inches, was inserted into the 2-inch fill pipe, extending down into it about 12 inches. Ordinarily, when the tank was not being refilled, a brass vent cover, hinged to the fill head, was shut so as to cover both the fill pipe and the vent holes. This cover could be locked in its closed position by a padlock as a protection against the theft of gasoline.

When a loose hose nozzle discharges gasoline into a properly vented storage tank, it acts on the principle of an inspirator in causing air to be drawn down into the tank. There the mixture of the air with the gasoline vapor may produce a dangerous condition of inflammability, leading to possible fires or explosions. Even the so-called vent pipe may introduce a similar situation of dangerous vapor–air mixture within a tank. In general, a vent pipe would be more appropriately called a "breather," because air flows inward through it when gasoline is being pumped out and the vapor–air mixture flows outward when gasoline is being discharged into the tank. In the peculiar and dangerous type of combined vent- and fill-pipe construction employed in

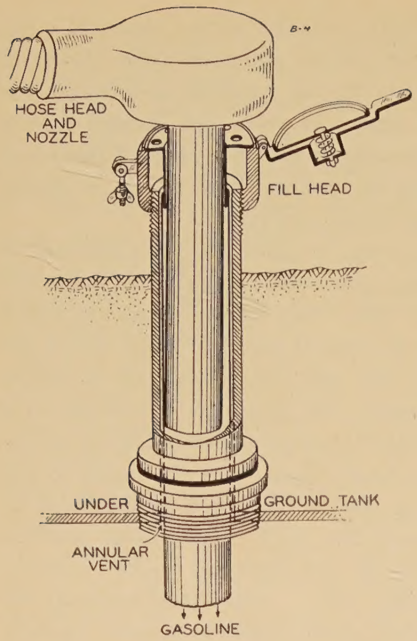

Figure 4. Diagram of the combined fill and vent pipe, showing (1) the gross inadequacy of the annular vent—only 1/15 of the cross section of the fill pipe; (2) the hazardous design which combines vent pipe and fill pipe in one unit; (3) the position of the hose nozzle in the fill pipe and the locations where igniting sparks may occur

this case, the vapor–air mixture was discharged at a high velocity, not only through the six small orifices but also through the fill pipe, during the time that the tank was being refilled with gasoline. This geyserlike condition of combustible gas, and the presence of the inflammable mixture at and near the orifices of the tank, both constituted particularly serious sources of potential fire hazards.

At the time that the fire occurred, the storage tank was in the process of being filled from a tank truck drawn up alongside, as shown in Figure 3. The fill hose used in this instance also was rated at approximately 50 gallons per minute, and about 80 gallons of gasoline had already been discharged, when the fire suddenly burst out of the combined fill pipe and vent pipe.

The engine of this tank truck, unlike that in the first case, was running at idling speed during this period—a circumstance flagrantly in violation of various codes of safety recommendations. The close proximity of the truck's engine to the fill pipe suggested the possibility of ignition of the expelled gasoline vapor–air mixture: (1) by electric sparks from a punctured high-voltage sparkplug cable, (2) by electric sparks from a defective distributor head in the ignition system, (3) by exhaust flames issuing from a loose or broken gasket in the exhaust pipe, especially at the manifold of the engine, and (4) by glowing carbon particles being blown out of the exhaust pipe.

Each of these four possible sources of ignition was given critical consideration. It was clearly recognized that if the engine of the truck had been operating under heavy load any one of these offending elements, if present at all, might have occurred at its severest intensity, and in consequence could have constituted a hazardous source of ignition in the presence of a combustible mixture of gasoline vapor and air. On the other hand, while the engine was idling, the intensity of any one of these four elements, if present, was not considered to present any real probability of igniting a mixture believed to be, because of the considerable distance between the truck and the fill head, much too lean for inflammability.

After detailed consideration of those four remotely possible causes for the fire, attention was directed to a study of the static electricity generated by the flow of gasoline in the fill hose, as being the most likely source of ignition of the inflammable gas mixture. As a first step in this investigation, the electric resistance between the metal of the storage tank and the surrounding ground was measured and found to be practically nil—actually about six ohms. This result gave evidence that no electrostatic capacitance between tank and ground, like that which existed in the insulated storage tank of the first case, was present here. Unique and critical circumstances did exist in this instance, however, as the result of the unsafe and careless methods employed by the operator of the gasoline truck in refueling the tank, and of the hazardous nature of the combined vent and fill pipes.

In the process of refilling the gasoline storage tank, the operator inserted the hose nozzle loosely into the fill pipe and then opened the valve at the side of the tank truck. He had neither made any previous ground-wire connections from the tank truck to an adequate and satisfactory ground, nor lowered a drag chain to ground the chassis of the truck to the dirt surface of the yard. Had either of these customary safety practices been employed, the fire most probably would have been averted. Also, fire undoubtedly would have been prevented by simply using, in the first place, the highly approved and extensively used "screw-in" type of hose nozzle, rather than the hazardous "loose" type. By municipal regulations, the screw-in hose nozzle is required in the filling of gasoline storage tanks in practically every large city in the United States. This attachment consists of a separate short piece of pipe, 2-inch pipe in this case, which is threaded at each end to enable it to be screwed securely into the fill pipe at one end and into the brass head of the hose at the other end.

The standard fill hoses in use for refilling storage tanks, as previously stated, contain wires interwoven in the hose fabric to connect the metal of the truck to the hose nozzle, so that during unloading operations, it will presumably ground the truck body to the storage tank. If the nozzle of the hose had made proper and continuous metallic connection with the fill pipe in this instance, the truck body would have been electrically grounded. Unfortunately, however, the loose hose nozzle cannot be relied upon as a means of grounding a tank truck, for the reasons to be described.

Dielectric tests taken on samples of gasoline by means of a standard American Society for Testing Materials test cell disclosed that its dielectric strength was of the same general order as that for high-grade transformer oil.

Most of the 100 or more tests made by the author showed dielectric values higher by several per cent for gasoline than for the oil. This finding has a particularly significant bearing upon the unreliability of the loose hose nozzle as a means of grounding the body of the truck. When the hose nozzle was placed in the fill pipe, it made contact with it at two locations, one being at the top of the fill pipe and the other at the lower end of the nozzle. Obviously at this lower end where the fluid discharges, the pipe was kept wet with the splashing gasoline—a condition which established and maintained an excellent insulating film between the metal of the nozzle and the pipe. Since the fill pipe also served in this instance to vent the tank, a gasoline insulating film was undoubtedly produced from the rising spray at the top between the nozzle and the head of the fill pipe, and in addition this was augmented by an insulating barrier resulting from layers of nonconducting metallic oxides and possibly from intervening particles of dirt. The metal structure of the truck was, of course, well insulated from ground by the dry rubber tires. In consequence, whatever electric charges were generated on the metallic structure of the truck and the hose by the flow of gasoline to the storage tank were impounded there by virtue of the insulated hose nozzle until a voltage to ground was developed of sufficiently high intensity to cause the ultimate passage of a spark.

When gasoline was permitted to flow through the fill hose into the storage tank, it became charged with electricity by the principle of "contact difference of potential." Under such circumstances the liquid generally acquires a positive polarity, and the counterpart negative charges are thereby contained in and impounded on the related metal parts—in this instance the tank truck and its connecting hose, because they were insulated from ground. The author employed information, which he also substantiated by test, to the effect that gasoline, in flowing at the rate of about 50 gallons per minute, produces electric charges in the flowing gasoline which correspond to a current of about 3×10^{-8} ampere.

Since the hose in this case was rated at a flow of approximately 50 gallons per minute, the rate at which the positive electric charges were conveyed into the storage tank and the negative charges stored in the insulated metallic system of the truck and hose was 3×10^{-8} ampere. For the period of approximately 100 seconds during which the 80 gallons of gasoline flowed into the storage tank just prior to the fire, a total electric charge of 3×10^{-6} coulomb accumulated on the truck. With respect to ground, this truck possessed a capacitance of approximately 750 micromicrofarads, or 7.5×10^{-10} farad. From the basic equation that volts = coulombs ÷ farads, the voltage which existed from the truck and its hose to ground was readily calculated and found to be approximately 4,000 volts.

Apparently when this value of voltage was attained after the passage of the 80 gallons of gasoline, one of the insulating films between the hose nozzle and the fill pipe disrupted under the increasing potential stress and thereby permitted the complete and instantaneous electric discharge of the truck, as a capacitor, through its ensuing spark. In the presence of the mixture of gasoline vapor and air at the proper proportion for inflammability, such a spark would be a "competent producing cause" for starting the fire.

The intensity of static electric sparks in relation to their ability to ignite an inflammable gas mixture is interesting to consider. During winter months a person scuffing over a woolen rug may readily store upon his body, as a capacitor, an electrification to a potential difference of 4,000 volts, or even more. By experiment, this voltage and charge have been found sufficient to ignite illuminating gas from a jet by bringing the knuckle close to the burner when the gas is turned on. Under approximately the same value of voltage, the truck being considered here, which had a capacitance of about seven times that of the human body, would have stored upon it approximately seven times the above quantity of electricity and, therefore, upon discharge, it would have given a spark of about seven times the intensity of that just cited as being sufficient to light a gas jet.

For the production of gasoline fires from electrostatic sparks of such short periods as existed here which result from the discharge of a capacitor, that is, from the sparking of the truck body through the hose nozzle to ground, the amount of heat energy contained in the spark is the true criterion for ignition. The heat energy required to produce the temperature of 1,760 degrees Fahrenheit necessary for the instantaneous ignition of an inflammable mixture of gasoline vapor with air at atmospheric pressure, particularly at ultrashort intervals of microsecond or less, has not as yet been determined. The author has been making a quantitative investigation of this problem, however, and hopes to have information available in the near future. In this instance the author computed from the known data the value of the electric energy liberated when the spark occurred at the fill pipe to discharge the truck body. From the basic equation, energy $= {}^1/_2 QE$, he found the energy to be approximately 6×10^{-3} watt-second, or 1.44×10^{-3} calorie. As previously mentioned, this is about seven times greater than that required to light the gas jet from the charge liberated at a person's knuckle. The value of the current at the first instant of the discharge is probably of the order of several amperes. At start, it is limited only by the resistance in the electric spark. Thereafter the current quickly decays in a logarithmic manner, according to the equation $i = I_0 e^{-\frac{t}{RC}}$, where i represents the current at any instant t, and I_0 is the initial value of the current, which is numerically equal in this instance to $4{,}000/R$. The value of R is not only unknown here, but also, so little is known concerning the resistance of arcs, it cannot even be approximated within reasonable limits without specific investigation. The time constant, $T = CR$, is very small, perhaps of the order of 7.5×10^{-7} to 7.5×10^{-8} seconds.

The hazardous type of combined fill and vent pipe used in this tank, the author was informed, would have been promptly disapproved by the National Board of Fire Underwriters. The dispelled vapor was exhausted at high velocity both from the small holes in the fill head and from the fill pipe as well—a dangerous condition in itself. The high ambient temperature on the day of the fire—82 degrees Fahrenheit—greatly expedited the admixture of air and gasoline vapor to the point of inflammability. So, therefore, when a spark occurred near the orifice of the fill pipe at the instant prior to the start of the fire, all the conditions for the ignition of the gas mixture were apparently fulfilled, and a fire ensued which completely destroyed the garage and several cars, a lubritorium, a sales display room, supplies, and offices.

CONCLUSIONS

From a critical study of all the available facts and data in each of the two illustrative examples cited in this article, several interesting conclusions were adduced. In each of the two cases, strong and well-integrated circumstantial evidence indicated "with a reasonable degree of certainty" that the fires were caused by spark discharges of electrostatic origin.

In the first case, none of the ordinary sources of ignition for the fire could be discovered which had any supporting evidence at all. The very unusual situation of the tank being unwittingly insulated from the ground provided a rational basis for concluding, with a reasonable degree of certainty, that a spark from the discharge of the electrified tank through the dielectric to ground caused the ignition of the highly inflammable gasoline vapor–air mixture.

Had the ground wire, which was so meticulously connected to the insulated vent pipe of the tank with the belief that this had grounded the truck, actually been joined to a well-grounded conductor, the electric charge on the truck would have been harmlessly discharged and no fire from this cause could have resulted. Likewise, had the vent pipe been connected to, and run up the side of, the adjacent building wall to the recommended height of ten feet above the roof, the expelled vapor would then have been too thoroughly diffused to produce an inflammable mixture with air at the outer walls of the buried tank.

In the second example, singularly enough, the fire occurred as the result of another very uncommon situation of a still different kind, and of a violation of well-established safety recommendations. The storage tank itself was quite well grounded, but no attempt had been made to ground the tank truck by either a ground wire or a drag chain. It was probably believed—if, indeed, any thought was given to the subject at all—that the grounding of the truck had been accomplished through the "ground wires" interwoven in the fill hose. But, as already explained, the hose nozzle was effectively insulated from ground by the high dielectric property of the intervening films of gasoline and metallic oxides, and, therefore, the tank truck and its connected hose were unknowingly insulated from ground—a condition which, during the handling of gasoline, is at all times most dangerous. Under such circumstances a single spark from an electrostatic discharge at the hose nozzle in the presence of the inflammable gas mixture would suffice to cause a fire or an explosion.

Then, too, the vent from the storage tank discharged its gas mixture into the air at the most unfavorable location, where the hazards of fire were greatest. The most dangerous location in the filling operations of a tank, where a loose hose nozzle is employed, is at the fill pipe, because static electric sparks here are known to have caused many fires and serious explosions. If the screw-in type of hose connection to the fill pipe had been employed, as has been recommended for years by the National Board of Fire Underwriters and by other safety organizations, the electric charge on the truck would have flowed harmlessly to ground, a high voltage from the truck to ground could not have been developed, as explained, and, in consequence, no fire could have occurred.

Other possible sources of fire may have been present in the second case, because the idling engine of the truck was located within a few feet of the fill pipe. Yet automotive vehicles by the thousands are daily serviced with gasoline, apparently with impunity, while their engines are running. With a wide experience in investigating the origins of gasoline fires, one would place little credence in a claim that the fire in this instance started from this cause. The high vertical velocity of the escaping gas mixture at the tiny vent holes and the fill hole would cause the gasoline vapor to become excessively diffused with air by the time it gravitated into proximity with the engine.

Thus, from these two and the many other casualties from gasoline fires and explosions that have been investigated by the author, he has found repeatedly that the so-called "inexplicable mysteries" of their origins generally dissolve into the commonplace when exposed to the illuminating facts and data revealed from an investigation of every pertinent channel of engineering knowledge and science by persistent, painstaking, and understanding research and study.

Finally, where gasoline fires and explosions have occurred, their origins have generally sprung either from the neglect of safe and accepted practices in the handling of gasoline on the part of the employees of the local oil companies or of garage attendants, or from the existence of unusual circumstances which were generally the outgrowth of inexcusable ignorance of the lurking fire hazards peculiar to the oil industry or of lack of intelligent supervision and inspection of the installations of gasoline-storage facilities.

Simplified Calculation of Fault Currents

A simplified procedure for the calculation of short-circuit currents was presented in an earlier report.[1] This procedure, outlined in this article, has been given trial use for over a year and has been found to be generally satisfactory for the purpose intended. Accordingly, it is now recommended for general use by the industry as a simplified method of approximating the magnitude of fault currents.

THE precise determination of short-circuit currents involves a calculation so laborious as to be generally impractical. Thus, some approximation is required, and a degree of judgment must be applied in any method proposed. This method presented here is based upon the determination of an initial value of rms symmetrical current with which multiplying factors are used for application purposes. It is proposed that it be used, where applicable, in place of the methods which involve the use of decrement curves. It is believed that this procedure is sufficiently accurate to serve as a reliable basis for the application of interrupting devices and for a preliminary basis for relay settings.

The recommended multiplying factors take account of generator decrement and the asymmetrical value of current as influenced by the system d-c time constant, and they are adjusted to make allowance for the increase in generator excitation required to maintain normal terminal voltage under load conditions. They neglect, however, such influences as generator voltage regulators and phase-angle differences between generator rotors, which have but little effect within the usual operating time of modern circuit breakers.

A comparison of the current magnitudes determined by the recommended factors with those calculated by more complicated methods after various time intervals is given in Figure 1. The time intervals selected correspond to breaker speeds of 2, 3, 5, and 8 cycles. The fault current and reactances are based on the system kilovolt-amperes. Curves are given for both the total rms current and the a-c component only, the difference between the two being due to the d-c component. The larger the d-c time constant, the more closely is the total rms curve approached, and the smaller the d-c time constant, the more closely is the a-c component curve approached. The time constant of the d-c component for which these curves were made is 0.15 second or nine cycles, which is larger than the values usually encountered in any equipment except generators. The d-c time constant may be expressed generally as equal to $(1/2\pi f)(X/R)$ in seconds, or $(1/2\pi)(X/R)$ in cycles, where X is the 60-cycle reactance and R the d-c resistance to the point of fault.

In this method of determining fault currents, symbols are used with the following significance:

E = leg voltage
X_1 = direct-axis reactance, either transient or subtransient as specified, in ohms per leg
X_2 = negative-sequence reactance
X_0 = zero-sequence reactance
R_0 = zero-sequence resistance

The type of fault (number of phases involved, with or without ground) which will result in the maximum fault current varies with the relative values of the different circuit constants.

The three-phase short-circuit current is E/X_1. The line-to-line short-circuit current is $\sqrt{3}E/(X_1+X_2)$. Since X_2 is usually equal to or greater than X_1, this current seldom exceeds 86 per cent of the three-phase short-circuit current, and, consequently, for line-to-line faults the three-phase fault-current value is generally satisfactory.

The line-to-ground short-circuit current is $3E/(X_1+X_2+X_0)$. Since X_2 is usually approximately equal to X_1 (using the subtransient value for X_1), this expression is often shortened to $3E/(2X_1+X_0)$. In practical cases, regardless of the value X_2, this last expression is satisfactory for determining the current in a double line-to-ground fault.

PROCEDURE

The following gives a résumé of the procedure and the various multiplying factors to be used with currents calculated by the formulas just stated. Tables I and II show what reactance quantity should be used for representing the machines in the positive-sequence network.

Circuit Breakers, Protector Tubes, and Fuses. Determine "highest value of rms symmetrical current for any type of fault" by E/X_1 or $3E/(2X_1+X_0)$, whichever is greater, except that when R_0 is greater than $5X_1$, no consideration need be given to the latter term. Use multiplying factors as given in Table I for specific type of apparatus.

The application of protector tubes requires also the calculation of minimum fault current with minimum connected synchronous capacity and symmetrical current using E/X_1 or $3E/(2X_1+X_0)$, whichever gives the lower value. Special consideration is required where tower-footing resistance can appreciably reduce this line-to-ground fault current. For further details reference may be made to a paper, "Protector Tubes for Power Systems."[2]

Fuses are rated on total current, and, as the time durations involved are very short, their required inter-

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This report, sponsored by the AIEE committee on protective devices (J. R. North, chairman 1940–42) was prepared by a working group consisting of W. F. Skeats, W. M. Hanna, J. B. MacNeill, H. A. Travers, C. F. Wagner, and C. A. Woodrow.

Reprints of this report are being made available; see page 526 of this issue.

rupting capacity should be based on the total rms current at one-half cycle. Two cases should be considered:

1. In the general case, the current multiplying factor is 1.6, using subtransient reactance for all machines, and including both synchronous- and induction-motor contributions.

2. For fuses rated 15,000 volts or below with interrupting ratings not exceeding 3,000 amperes (except when applied on a generator bus), the resistance introduced by line and transformer is so great that the rms current of a maximum displaced wave in the first half cycle will not exceed 1.2 times the calculated symmetrical current, using subtransient reactance. Application on this basis may be considered safe.

Mechanical and Momentary Ratings. For many purposes, it is necessary to know the maximum possible rms current which can flow in the circuit. This is the current, including both a-c and d-c components, as calculated at one-half cycle. Allowing for over excitation of generators on account of load, the rms value of current as calculated for zero time is about 1.8 times the value calculated by dividing leg voltage by subtransient reactance. As there will always be some decay even in the first half cycle, however, a multiplier of 1.6 gives a safe figure.

In some instances, as when transmission line or cable reactance is an important factor in the limitation of current, the factor 1.6 may be higher than necessary. In such applications at 5,000 volts and below, the ratio of reactance to resistance is sufficiently low so that the d-c component decreases very greatly during the first half cycle. Thus within this voltage range, and except where the bulk of the power is supplied by generators at the point of fault, a standard factor of 1.4 may be used instead of 1.6. A standard factor is particularly desirable, in consideration of the difficulties of obtaining actual resistance figures and the distribution of the d-c component among contributing short-circuit sources.

Low-Voltage Systems. Low-voltage air circuit breakers (rated 600 volts or less) are often instantaneous in operation and part contacts during the first half cycle. These breakers, however, are rated on the basis of average current in the three phases, and circuits on which they are installed rarely have X/R ratios exceeding 10. This corresponds to an average rms current during the first cycle equal to 1.23 times the symmetrical current. Such breakers may therefore be applied on the basis of 1.25 times the three-phase initial symmetrical current using subtransient reactance and including both synchronous and induction motors.

Table I. Circuit Breakers, Protector Tubes, and Fuses

	Multiplying Factor	Reactance Quantity for Use in X_1: Synchronous Generator	Reactance Quantity for Use in X_1: Synchronous Motor	Reactance Quantity for Use in X_1: Induction Machine
A. Circuit-Breaker Interrupting Capacity				
1. General case				
Eight-cycle or slower breakers ♯	1.0	Subtransient*	Transient	
Five-cycle breaker	1.1			
Three-cycle breaker	1.2			
Two-cycle breaker	1.4			
2. Short circuits fed predominantly by large machines at the point of fault may be increased up to 20 per cent				
3. Air circuit breakers rated 600 volts and less	1.25	Subtransient	Subtransient	Subtransient
B. Mechanical Stresses and Momentary Rating of Circuit Breakers				
1. General case	1.6	Subtransient	Subtransient	Subtransient
2. At 5,000 volts and below, unless current is fed predominantly by directly connected synchronous machines or through reactors	1.4			
C. Protector Tubes				
1. Maximum rating	1.0	Subtransient	Subtransient	Subtransient
2. Minimum rating—use minimum system capacity and minimum of E/X_1 or $3E/(2X_1+X_0)$				
D. Fuses				
1. General case	1.6	Subtransient	Subtransient	Subtransient
2. At 15,000 volts or below with interrupting ratings not exceeding 3,000 amperes	1.2			

♯ Modern breakers are likely to be more effective than their slower predecessors, and, therefore, the application procedure with the older breakers should be more conservative than with modern breakers. Consequently, the factors to be used with older and slower breakers should be the same as for modern eight-cycle breakers.

* This is based on the condition that any hydroelectric generators involved have amortisseur windings. For hydroelectric generators without amortisseur windings, the subtransient reactance should be assumed equal to 75 per cent of the transient reactance for this calculation.

Table II. Preliminary Settings for Relays

	Multiplying Factor	Reactance Quantity for Use in X_1: Synchronous Generator	Reactance Quantity for Use in X_1: Synchronous Motor	Reactance Quantity for Use in X_1: Induction Machine
1. High-speed current actuated	1.0	Subtransient	Subtransient	Subtransient
2. Time overcurrent	1.0	Transient	Transient	

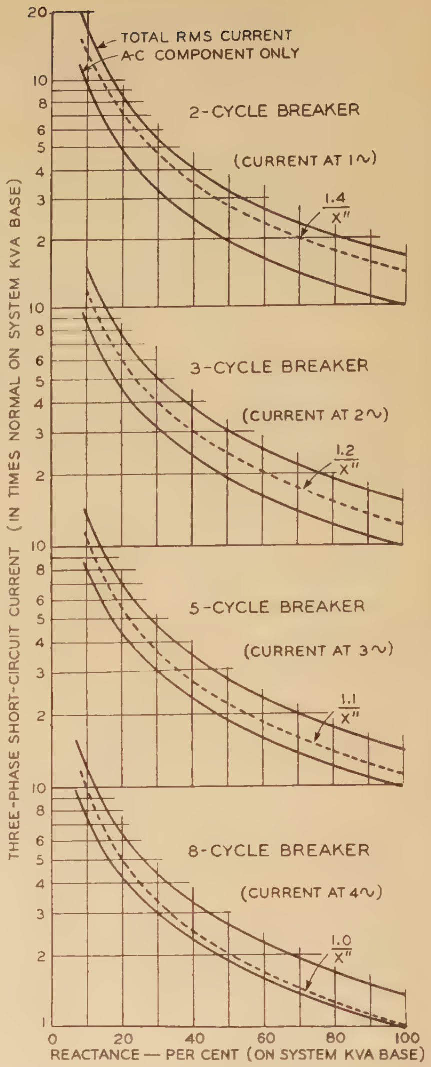

Figure 1. Comparison between decrement curve calculations and calculations by the proposed method

In calculating the equivalent system impedances, it should be remembered that at low voltages even small impedance values become of importance, and all elements of the circuit, including current transformers, disconnects, switches, bus runs, and lead wires, should be taken into consideration.

Overcurrent Protective Relays. In approximating the settings of overcurrent relays, the fault currents for two conditions should be determined:

1. The maximum initial symmetrical current for maximum connected synchronous capacity as determined by E/X_1 or $3E/(2X_1+X_0)$, whichever is greater, except that, when R_0 is greater than $5X_1$, no consideration need be given to the latter term.
2. The minimum symmetrical current for minimum connected synchronous capacity as determined by $0.866E/X_1$. In particular situations allowance should be made for remote fault locations and fault resistance.

Ground, distance, balanced, and other types of relays require special consideration.

REFERENCES

1. System Short-Circuit Currents, **W. M. Hanna, H. A. Travers, C. F. Wagner, C. A. Woodrow, W. F. Skeats.** AIEE *Transactions*, volume 60, 1941, September section, pages 877–81.

2. Protector Tubes for Power Systems, **H. A. Peterson, W. J. Rudge, Jr., A. C. Monteith, L. R. Ludwig.** AIEE *Transactions*, volume 59, 1940, May section, pages 282–92.

Some Aspects of the Electromagnetic Field

LEIGH PAGE

"The rotating armatures of every generator and every motor in this age of electricity are steadily proclaiming the truth of the relativity theory to all who have ears to hear," declares this well-known physicist, who traces the development of electromagnetic theory from the 18th century to the impact of relativity.

IT SEEMS very strange that, although the Greeks were aware of the attractions of electrified and of magnetized bodies as early as the sixth century before Christ, over 2,000 years should have elapsed before anyone showed sufficient scientific curiosity to perform the simple experiments necessary to determine the quantitative law of force. Michell, of Queen's College, Cambridge, in 1750 seems to have been the first to have established the law of force between magnetic poles. Another Englishman, Cavendish, discovered the law of force between electric charges about 1770, but failed to make his work public. The first to publish the results of accurate experiments verifying the inverse-square law of force for both electric charges and magnetic poles, performed with the aid of his newly invented torsion balance, was the French physicist Coulomb in the year 1785. Thus the quantitative foundations of the great science of electromagnetism were laid only a little more than a century and a half ago.

At first progress was slow. The phenomena of electrification and of magnetization appeared to be distinct and unrelated, and it seemed only accident—or perhaps a consequence of the three-dimensional structure of the universe in which we live—that the law of interaction should in each case be the same inverse-square law that had been discovered by Newton a century earlier in the field of gravitation. It was not until 1819 that it occurred to Oersted of Copenhagen that the disturbance of a compass needle during a thunderstorm indicated that an electric current affects a magnetic needle. In his subsequent experiments he first placed a needle at right angles to a wire carrying a current, and was disappointed to observe no effect; when, however, he placed the needle parallel to the wire he found that it turned until it was perpendicular, and in opposite senses according as the needle was placed below or above the current. On September 11, 1820, Oersted's discovery was reported at a meeting of the French Academy, and one week later Ampère announced the discovery of the magnetic interaction between current circuits. In a remarkably short time he performed the crucial experiments that led to his celebrated law of force between current elements. While we know today that this law of force is not correct for two isolated current elements, such as two moving electrons, yet it always leads to correct values of the integrated force when applied to closed circuits carrying steady currents.

Progress was now more rapid. In 1831 Joseph Henry in America and Michael Faraday in England discovered independently the electromotive force due to change in magnetic flux. Although Henry's work unquestionably preceded Faraday's, Faraday is accorded the credit for

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this epoch-making discovery on account of his earlier publication. Faraday was led to his investigations by the feeling that electrostatic induction should have a counterpart in the field of current electricity. While he did not find precisely what he had expected, he was observant enough to note the momentary current in the one circuit when the current in the other changed. Although Neumann in 1845 was the first to express Faraday's discovery in analytical form, Faraday had already given a quantitative description of the phenomenon in terms of lines of force, and it is only appropriate that the law describing his great discovery should bear his name.

The final step in the evolution of the equations of the electromagnetic field was taken by Maxwell in 1864. Unlike the discoveries of Coulomb, Oersted and Ampère, Henry and Faraday, which were based on observation and experiment, Maxwell's great discovery was entirely theoretical—the result of careful examination, bold surmise, and correct reasoning. In modern notation, work prior to Maxwell can be summed up in the field equations

$$\nabla\cdot\mathbf{D}=\rho \tag{1}$$

$$\nabla\cdot\mathbf{B}=0 \tag{2}$$

$$\nabla\times\mathbf{E}=-\frac{1}{c}\dot{\mathbf{B}} \tag{3}$$

$$\nabla\times\mathbf{H}=\frac{1}{c}\,\rho\mathbf{v} \tag{4}$$

where $\mathbf{D}$ is the electric displacement, $\mathbf{B}$ the magnetic induction, $\mathbf{E}$ the electric intensity, $\mathbf{H}$ the magnetic intensity, ρ the charge density, and $\rho\mathbf{v}$ the current density, all in Heaviside–Lorentz units. The symbol $\nabla\cdot$ represents the divergence, $\nabla\times$ the curl, and a dot over a letter the time derivative.

The first two of these equations express the results of Coulomb's work, equation 3 is Faraday's law for the induced electromotive force due to change of magnetic flux, and equation 4 is Ampère's law for the magnetic field produced by a current. Maxwell's great contribution sprang from his observation that these equations fail to satisfy the equation of continuity, which must hold if electricity is conserved. To make the field equations consistent with this essential relation, he found it necessary to replace equation 4 by the Ampère–Maxwell law

$$\nabla\times\mathbf{H}=\frac{1}{c}\,(\dot{\mathbf{D}}+\rho\mathbf{v})$$

Maxwell's innovation makes Ampère's law in empty space the exact counterpart of Faraday's law. It demands the presence of a magnetomotive force whenever there is a change in electric flux. Why, then, is not this magnetomotive force observable experimentally with the same facility as the electromotive force described by Faraday's law? The answer, of course, is that nature provides us with no methods of detecting a magnetomotive force comparable in delicacy with those we use for measuring an electromotive force.

Maxwell's correction to Ampère's law led to a startling consequence. The second-order differential equation for *one* of the field intensities in empty space, obtained by eliminating the *other* field intensity from the first-order equations, proved to be the equation of a wave traveling with a velocity equal to the ratio c of the electromagnetic to the electrostatic unit of charge. It had already been noticed that this ratio was identical, within the limits of experimental error, with the velocity of light. The electromagnetic theory of light, confirmed subsequently in so many of its intricate details, was inevitable. Today the gamut of explored electromagnetic waves extends from the radio waves of several kilometers length through the infrared, the visible octave, the ultraviolet and X-ray region, the gamma rays emitted in radioactive disintegrations, to the cosmic rays. Maxwell could not envisage the immense wealth of the field to which he had opened the gate. He even doubted that it would be possible to construct apparatus delicate enough to produce and to detect the electromagnetic waves demanded by his theory. In fact this was not accomplished until Hertz performed his historic experiments of 1888.

The four field equations, in the form given them by Maxwell, describe only one aspect of the phenomena of electromagnetism. They specify the electric and magnetic fields produced by any assigned distribution of charge and current. But it is equally important to know the forces or torques exerted on charges or currents placed in a field produced by some outside agency. This information is contained in the force equation, which was perhaps best formulated by the late Dutch physicist, H. A. Lorentz. The four field equations and the force equation, together with such constitutive relations between $\mathbf{D}$ and $\mathbf{E}$ on the one hand and between $\mathbf{B}$ and $\mathbf{H}$ on the other as are necessary to describe the properties of a material medium, and Ohm's law for the relation between current density and electric field intensity, constitute the complete set of electromagnetic equations.

Velocities appear in these equations only in connection with the motion of charges; that is, electric currents. There is no reference to motion of a field. The concept of moving lines of force of a magnetic field, producing an electromotive force when they cut a conductor, so much used in teaching elementary physics and electrical engineering, is quite extraneous to Maxwell's theory. Of course this concept, when applied to a *closed* circuit, will always lead to correct results for the *integrated* electromotive force, even though it may lead to an erroneous *distribution* of electromotive force around the circuit, for in this case it gives just the time rate of change of flux. But this concept may lead to utterly wrong conclusions in the case of an open circuit. The classical example is that of a cylindrical magnet (Figure 1) mounted so that it may be given a spin about its axis of symmetry *SN*. Let a piece of wire *AB* be placed at right angles to the magnet near its center on a line passing through the axis of the magnet. Then, if its field rotates with the magnet, we would expect on the moving-line concept that there would be an electromotive force along the wire when the magnet rotates and the wire is stationary, and none when the two rotate together. The electromagnetic equations, on the contrary, predict the exact opposite in each instance. In 1912 Barnett performed this experiment, and completely disproved the moving-line concept. In a recent book Cullwick attempted to show that the moving-line concept would lead to correct results if the charges produced on the rotating conductor were taken into account, but his analysis was faulty, as he has since admitted.

The moving-line concept cannot be saved by assuming that a magnetic field follows the magnet producing it without rotating, for even this assumption, when we integrate the effects due to all the filaments comprising the rotating magnet, leads to a residual, if smaller, electromotive force along the stationary wire.

It seems unfortunate, therefore, that a concept, wrong in theory and disproved by experiment, should be so commonly taught and used, particularly in view of the fact that the correct concept is equally simple.

The electromagnetic equations distinguish two fundamentally different types of electromotive force. First we have the electromotive force described by Faraday's law (equation 3). This is the electromotive force produced by a changing magnetic flux through a circuit *fixed* in the observer's inertial system. It is exemplified by the transformer. The changing magnetic field is, of necessity, accompanied by an electric field, of which the lines of force form closed loops and therefore give rise to an electromotive force around a properly oriented closed circuit. It must be emphasized that this electric field exists in the observer's inertial system whether a conducting circuit is present or not. It is a field very different from that produced by a static distribution of charges, in that it is not expressible as the gradient of a single-valued scalar potential function.

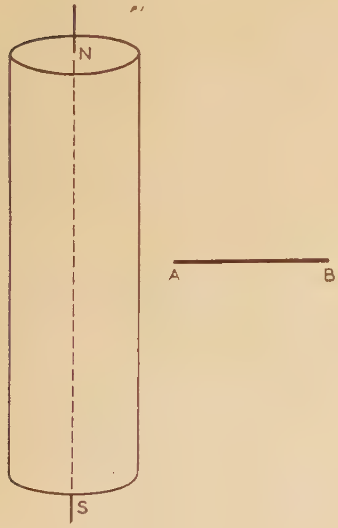

Figure 1

The second type of electromotive force, differentiated from the first by the addition of the adjective "motional," has its origin in the second term of the force equation. This important electromotive force is exhibited in the rotating armature coils of a generator. It comes into being whenever a conducting wire *moves relative to the observer* through a magnetic field. The electric field in the inertial system of the moving wire, which it implies, is nonexistent in the observer's inertial system, as is evident from the fact that no electromotive force is discernible when the wire is at rest relative to the observer.

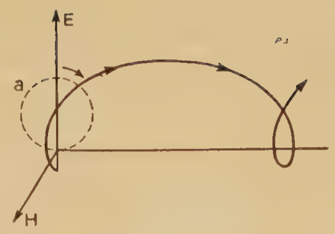

Figure 2

These characteristics of motional electromotive forces are leading us straight to the relativity theory. Before discussing the impact of that theory on the subject of electromagnetism, let us examine another simple electromagnetic phenomenon illustrating the fact, just brought out in connection with motional electromotive forces, that, although an observer in *one* inertial system may be aware of an electric field, an observer in *another* inertial system at the same place and at the same time may find no electric field at all. Consider a charged particle, such as a proton, which is projected into a uniform magnetostatic field in a direction at right angles to the lines of force. It will describe a circular path about the magnetic lines of force, with an angular velocity that is *independent* of the initial linear velocity or of the radius of the orbit. It is this property of its motion that makes possible the operation of the cyclotron.

Now suppose that in addition to the uniform magnetostatic field $\boldsymbol{H}$ we have present a uniform electrostatic field $\boldsymbol{E}$ at right angles as in Figure 2. Then the path of the proton is a cycloid generated by a rolling circle lying in a plane perpendicular to the magnetic lines of force and advancing in a direction at right angles to both fields with a constant speed depending only on the ratio of the field intensities. Let us examine the motion of the proton, now, from the point of view of an observer in an inertial system moving along with the center of the rolling circle a. To him the path is a circle about the magnetic lines of force. The effect of the electric field has vanished; indeed, he has no choice but to conclude that no electric field exists in his inertial system.

Even simpler are examples in which a magnetic field is annihilated by a change in the observer's state of motion. Consider a charge moving with constant velocity relative to one observer's inertial system. On account of its motion it constitutes a current element, and gives rise to a magnetic field. But to another observer located in the inertial system of the charge there is no motion and no magnetic field.

The special relativity theory enunciated by Einstein in 1905 does not say that all motion is relative. It asserts that the laws of nature are the same when referred to one inertial system as when referred to any other. Contrary to popular belief, the relativity theory is *not* based fundamentally on the negative result of the optical experiment performed by Michelson and Morley in the hope of detecting the motion of the earth relative to a hypothetical ether. It is a direct outgrowth of electromagnetic theory. In fact, Einstein's original paper is entitled "Zur Electrodynamik Vewegter Körper" (On the Electrodynamics of Moving Bodies). The space-time transformations of the theory had already been discovered by Lorentz as a result of his work on the electromagnetic theory of light in moving media. Einstein's great contribution was a new interpretation of these transformations.

Consider two inertial systems S and S', the second of which is moving relative to the first with a velocity v directed along the X axis. The relativity theory tells how to find the electromagnetic field in S' if we know that in S, or vice versa. For simplicity I shall confine myself to fields in empty space. Then, designating the field components in S' by primes,

$$\begin{aligned} E_x' &= E_x & H_x' &= H_x \\ E_y' &= k\{E_y - \beta H_z\} & H_y' &= k\{H_y + \beta E_z\} \\ E_z' &= k\{E_z + \beta H_y\} & H_z' &= k\{H_z - \beta E_y\} \end{aligned}$$

where $\beta \equiv v/c$ and $k \equiv 1/\sqrt{1-\beta^2}$, c being the velocity of light.

First we should like to know the invariants of these transformations; that is, the quantities which are the same to both observers. They are $\boldsymbol{E} \cdot \boldsymbol{H}$ and $E^2 - H^2$. The first tells us that if $\boldsymbol{E}$ and $\boldsymbol{H}$ observed in one inertial system are perpendicular, as in a wave front, they are perpendicular in all. The second tells us that the difference of the squares of the field strengths is the same in all inertial systems. Note that this does not represent the energy of the field, which is given by the sum of E^2 and H^2. In an electromagnetic wave, for instance, E and H are equal in all inertial systems. If the wave is advancing in the X direction, both E and H, as well as the frequency, are less as observed in S' than as observed in S.

If E and H are perpendicular and unequal we can always eliminate the smaller by giving the observer an appropriate velocity. Let E be along the Y axis and H along the Z axis. Then it is clear from the transformations for the components that the requisite velocity is $c(E/H)$ to annihilate E or $c(H/E)$ to annihilate H.

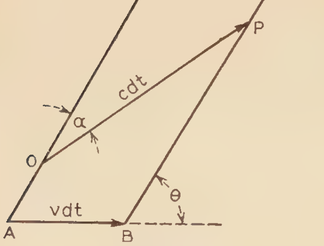

Figure 3

One can multiply examples. A simple case is that of a long charged parallel plate capacitor in S with the plates perpendicular to the Y axis. In S we have the electric field E_y and no magnetic field. In S', however, we have the stronger electric field $E_y' = kE_y$ and the magnetic field $H_z' = -k\beta E_y$. The strengthening of the electric field is due to the Fitzgerald–Lorentz contraction which makes the charge density on the plates greater in S' than in S, and the magnetic field is due to the current sheets consisting of the moving charged plates.

This analysis results in the recognition that there is no meaning to the assertion that here and now there exists a specified electric field and a specified magnetic field. All that can be said properly is that there exists a certain electromagnetic field: its resolution into electric and magnetic parts depends upon the state of motion of the observer.

Although I have criticized the *wrong* use of the representation of an electromagnetic field by lines of force, I do not wish to give the impression that this representation is not useful, and indeed highly significant. Faraday's introduction of this geometrical concept was perhaps one of the most important of his many contributions to science. In fact, by means of this concept we are able, with the aid of the relativity theory, to explain in a very fundamental way *why* a moving charge or current gives rise to a magnetic field and further actually to deduce both the Ampère–Maxwell law and Faraday's law from the simple inverse-square relation of Coulomb. If the relativity principle had been recognized in Coulomb's time, the experimental investigations of Oersted and Ampère, Henry and Faraday, would have been unnecessary.

Since electric charges exist in nature and are conserved, whereas magnetic charges do not exist at all, lines of electric force are far more fundamental than lines of magnetic force. In fact, the number of lines of electric force diverging from a given charge remains the same whatever we do to the charge. On the contrary, a charge at rest in the observer's inertial system has no magnetic field at all. When it is put into motion a previously nonexistent magnetic field is created.

The principle of relativity requires that every law of nature shall be the same and contain the same constants, no matter to what inertial system it is referred. Hence, if there exists a velocity law for the points or moving elements of which a line of electric force is the locus—and there is no reason to think that the lines of force in even a static field are subject to different laws from those in the wave front of a beam of visible light—the relativity theory requires that these moving elements shall move in straight lines with the velocity c of light, for this is the only velocity law which is the same relative to all inertial systems. One may question why one cannot equally well conclude that all shots fired from guns and all stones thrown by small boys should move with the velocity of light. The answer is that a complete velocity law does not exist for the motion of material particles. To be sure, a partial velocity law does hold, for we find that material particles in a field-free region move in straight lines relative to the observer's inertial system. Therefore the relativity principle requires that

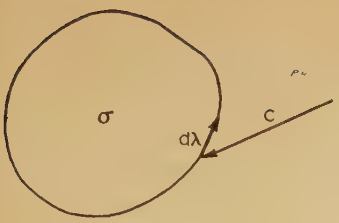

Figure 4

they shall move in straight lines relative to all inertial systems. But nature imposes no restriction on the speed of a material particle, other than that it shall be less than the velocity of light.

Consider first a point charge permanently at rest in the observer's inertial system. As its field is static, the motion in this case must be along the lines of force, and, in order to avoid teleological difficulties, we must imagine the charge itself to be a source of lines of force moving away from it with the velocity of light.

Next consider a charge in uniform motion relative to the observer. As it carries its field with it, the velocity $\mathbf{c}$, with which each line of electric force is moving, must make an angle with the line itself, which is greater the greater the velocity of the charge. The vector $(1/c)(\mathbf{c}\times\boldsymbol{E})$ represents exactly, both in magnitude and direction, the observed magnetic-field intensity. We do not make any assumption in identifying this vector with $\boldsymbol{H}$, because $\boldsymbol{H}$ is measured as a force or torque on some magnet or current, and when we have deduced the complete set of electromagnetic equations, we find a force depending on $(1/c)(\mathbf{c}\times\boldsymbol{E})$ in exactly the same manner as the force in the classical formulation depends on $\boldsymbol{H}$. In fact, it is quite simple to show that the vector $(1/c)(\mathbf{c}\times\boldsymbol{E})$ in the field of an elementary charge moving with constant velocity $\boldsymbol{v}$ small compared with that of light is identical with the magnetic field as specified by the modern version of Ampère's law. Let A (Figure 3) be the position of the charge e at time t and B its position at time $t+dt$. Then $OP=cdt$ and $AB=vdt$, and the vector $(1/c)(\mathbf{c}\times\boldsymbol{E})$ at P is a vector of magnitude E sin α directed out from the page. But $c\sin\alpha=v\sin\theta$ from the figure and in the Heaviside–Lorentz symmetrical units which are used here

$$\left|\frac{1}{c}\,\mathbf{c}\times\boldsymbol{E}\right|=E\,\frac{v}{c}\sin\theta=\frac{ev}{4\pi cr^2}\sin\theta$$

As the current element equivalent to ev is idl, where i is the current and dl an element of the circuit, we have finally

$$\left|\frac{1}{c}\,\mathbf{c}\times\boldsymbol{E}\right|=\frac{idl\sin\theta}{4\pi cr^2}$$

which is the usual form of Ampère's law in these units for a current element. The more familiar form of this law in electromagnetic units is obtained by multiplying by $4\pi c$.

A detailed analysis, first published 27 years ago, shows that Ampère's law, including Maxwell's correction, is nothing more than the kinematical equation of motion of the lines of electric force constituting the field of a charge. The proof is quite simple. Consider a bounded surface σ (Figure 4) *fixed* in the observer's inertial system. If N is the electric flux through this surface, the time rate of increase of electric flux is

$$\frac{dN}{dt}=\int_\sigma \dot{\boldsymbol{E}}\cdot d\boldsymbol{\sigma}$$

The part of this increase due to lines of force crossing the periphery from outside to within is

$$\oint \boldsymbol{E}\cdot d\boldsymbol{\lambda}\times\mathbf{c}=\oint \mathbf{c}\times\boldsymbol{E}\cdot d\boldsymbol{\lambda}=\int_\sigma \nabla\times(\mathbf{c}\times\boldsymbol{E})\cdot d\boldsymbol{\sigma}$$

and the part due to charge of volume density ρ crossing the surface with velocity $\boldsymbol{v}$ is

$$-\int_\sigma \rho\boldsymbol{v}\cdot d\boldsymbol{\sigma}$$

Adding these,

$$\frac{dN}{dt}=\int_\sigma \{\nabla\times(\mathbf{c}\times\boldsymbol{E})-\rho\boldsymbol{v}\}\cdot d\boldsymbol{\sigma}$$

Equating these two expressions for the time rate of increase of flux, and putting $\boldsymbol{H}$ for $(1/c)(\mathbf{c}\times\boldsymbol{E})$ we have the Ampère–Maxwell law

$$\nabla\times\boldsymbol{H}=\frac{1}{c}(\dot{\boldsymbol{E}}+\rho\boldsymbol{v})$$

This simple deduction does not even require the use of the space-time transformations of the relativity theory.

Faraday's law is deduced with equal rigor, although not so directly. Since any field, however complicated, is the resultant of the individual fields produced by the elementary charges and currents present, we can describe, in terms of lines of electric force moving with the velocity of light, the field of an elementary charge having any arbitrary velocity and acceleration relative to the observer's inertial system. Making use of the space-time transformations of the special relativity theory, we prove that $\boldsymbol{E}$ and $\boldsymbol{H}$ can be expressed in the forms

$$\boldsymbol{E}=-\nabla\phi-\frac{1}{c}\dot{\boldsymbol{A}}$$

$$\boldsymbol{H}=\nabla\times\boldsymbol{A}$$

in terms of a scalar potential ϕ and a vector potential $\boldsymbol{A}$. As any field may be regarded as the resultant of elementary fields of the type considered, these equations must hold for all electromagnetic fields.

Faraday's law follows immediately from this pair of relations. Taking the curl of the first and the time derivative of the second we obtain

$$\nabla\times\boldsymbol{E}=-\frac{1}{c}\dot{\boldsymbol{H}}$$

The transformations already stated for finding the electric and magnetic vectors in one inertial system from the known values of the field intensities in another are especially important, for it is by means of them that we deduce the term in the force equation specifying the force exerted by a magnetic field on a current. This term is responsible for the action of every generator or motor with a rotating armature.

These transformations are deduced quite easily from the concept of lines of electric force moving with velocity **c**. In the deduction, however, the relativity theory plays a very essential role. Consider a segment OP (Figure 5) of a line of force at time t in the observer's inertial system S, all points of which are moving with the velocity **c**. Here the two ends O and P of the segment are pictured at the *same* time t. Viewed from some other inertial system S', however, the events O and P are *not* simultaneous. If the time in S' at O is t', the time at P is less than t', if S' is moving to the right relative to S. At time t', P has moved up to Q. Hence the segment of the line of force at time t' in S' is OQ instead of OP. This relativistic aberration of the field accounts for the terms in $\boldsymbol{H}$ in the transformations of the components of $\boldsymbol{E}$.

The force equation is obtained immediately from the transformations for the components of $\boldsymbol{E}$, since we can always find an inertial system in which a moving charge is momentarily at rest. In that system the force on the charge is just the product of the magnitude of the charge by the electric field intensity. By transforming to the observer's system we find the force on a charge in motion, including as one term the force on a current element in a magnetic field.

The foregoing is sufficient to show that the rotating armatures of every generator and every motor in this age of electricity are steadily proclaiming the truth of the relativity theory to all who have ears to hear. If the Galilean–Newtonian concept of space-time were valid, many of my readers would be out of a job.

The representation just discussed is particularly useful in picturing graphically the propagation of electromagnetic waves from an accelerated charge. If a charge is executing linear harmonic vibrations, for instance, it is a simple matter to construct, with any degree of accuracy desired, the wavy lines of force of its field. In fact, the problem is identical with that of constructing the locus of the water particles shot out of a hose, the nozzle of which follows the motion of the charge. Figure 6 shows the evolution of such a line of force.

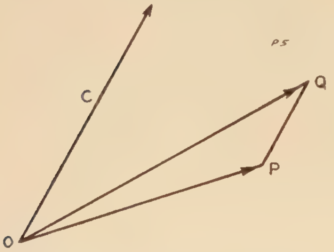

Figure 5

We have been educated to accept the dogma that nature provides us with electric charges, but with no magnetic charges. It is a simple matter to write down the field equations and the force equation which would hold in a world in which are present both electric and magnetic charges. On examining these equations we find that a simple transformation allows us to reduce them to the classical electromagnetic equations, provided, and only provided, that every charged particle carries electric and magnetic charges in the *same* ratio. With this provision, then, there is no electromagnetic experiment that can distinguish between our current concept of nature and one in which all charged particles are conceived to carry both electric and magnetic charges in a constant ratio. The assertion that only electric charges exist in nature is not a conclusion derived from observation and experiment, but a result of the *terms* in which we have chosen to interpret our experiments. Of course our usual interpretation is simpler than any other, and therefore more convenient.

I hope it is not inappropriate to emphasize, in conclusion, the esthetic qualities of electromagnetism. Of course we are aware that electromagnetic theory fails to cover the whole domain of physical phenomena. The theory breaks down when it is applied to atoms and molecules; that is, to phenomena on the ultramicroscopic level. Here the still mysterious and imperfectly understood quantum mechanics holds sway. But in the field in which it is competent, electromagnetic theory possesses a beauty of form and of interpretation never approached by any physical theory proposed before or since.

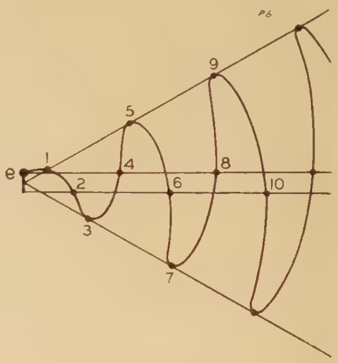

Figure 6

BIBLIOGRAPHY

The following references are given for the benefit of the reader who may wish to follow out in more detail the emission theory of electromagnetism.

1. Relativity and the Ether, **L. Page**. *American Journal of Science*, volume 38, August 1914, pages 465–72.

2. Structure of the Æther, **H. Bateman**. American Mathematical Society *Bulletin*, volume 21, March 1915, pages 299–309.

3. Lines of Electric Force Due to a Moving Electron, **F. D. Murnaghan**. *American Journal of Mathematics*, volume 39, 1917, pages 147–62.

4. **H. Bateman**. London Mathematical Society *Proceedings*, volume 18, 1919, page 95–135.

5. Kinematical Interpretation of Electromagnetism, **L. Page**. National Academy of Science *Proceedings*, volume 6, March 1920, pages 115–22.

6. **H. Bateman**. *Philosophical Magazine* (London), volume 41, 1921, page 107–130.

7. Generalization of Electrodynamics With Applications to the Structure of the Electron and to Nonradiating Orbits, **L. Page**. *Physical Review*, volume 18, October 1921, pages 292–302.

8. Introduction to Electrodynamics (book), **L. Page**. Ginn and Company, Boston, 1922.

9. Lines of Electric Force of a Moving Charge on the Emission Theory, **F. E. Hackett**. *Physical Review*, volume 21, April 1923, pages 465–72.

10. Intrinsic Magnetic Fields, **L. Page**. *Physical Review*, volume 22, August 1923, pages 188–97.

11. Electrodynamics (book), **L. Page, N. I. Adams**. D. Van Nostrand Company, New York, 1940. Chapter 3.

New Engineering and a New Industry

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FELLOW AIEE

NO ONE has yet succeeded in educating the public in what an engineer is and what he does, but we can say definitely what is *not* engineering. Anything that does not rest on a foundation of physics and mathematics is decidedly not engineering. Following the basic idea that engineering must rest on a foundation of physics and mathematics I will indulge in the attempt to establish two new definitions:

1. Rural-electrification engineering.
2. Electroagricultural engineering.

RURAL-ELECTRIFICATION ENGINEERING

This article reviews the present status of rural-electrification engineering, which has become established during the past few years, and points to the beginning of what the author terms "electroagricultural engineering," which deals with the applications of electricity on the farm. The author predicts that a new industry will be established to produce the equipment needed for these applications.

Rural-electrification engineering deals with the power supply to rural areas, including bringing power to a rural project and distributing it in the project to the consuming devices. It includes all problems involved in the study of the relative reliability of service of the different methods of power supply, relative costs, overcurrent protection, voltage regulation, protection against overvoltages, and similar problems that are definitely established as engineering.

About three years ago there was no rural-electrification engineering. A year ago we were just about in the process of creating one. Now the first chapter of rural-electrification engineering has been completed, the second chapter about half completed, and the third chapter just started. A pamphlet[1] known as "Rural Electrification Administration Technical Standards Bulletin No. 4" was issued in August 1941, and has already secured for itself the recognition of the profession as the first chapter of rural-electrification engineering. It covers what may be called the "ampere problems" in rural circuits. It deals with the computation of short circuits, the rationalizing or sectionalizing of the system, and the selection of protective devices against overcurrent. As has been the case throughout the history of electrical engineering, so here the analytical work resulted in new inventions and new developments. As the analytical work progressed it was found that certain devices required to solve the problems did not yet exist, and young engineers proceeded to invent them.

The second chapter might be called the broad problem of communication related to rural circuits. During the 1941 AIEE winter convention, a joint paper[2] by Rural Electrification Administration engineers and Bell Telephone Laboratories engineers was presented, covering the subject of telephone interference on rural circuits. This too is recognized as the basic paper on the problem and forms a beginning of the second chapter of rural-electrification engineering. The problem of carrier current has been covered in various ways and is still in the process of development. So is direct radio communication and its numerous diversifications.

The third chapter, that relating to voltage problems, is now in the process of being prepared. We started only a very short time ago and are now following the usual course of conservative engineering by first starting with cases. After we will have solved a number of cases we no doubt will generalize; we then hope to have a competent text on voltage-regulation problems specifically relating to rural circuits. No doubt the analytical work will bring out the need for new devices, and undoubtedly young engineers will invent them.

A thorough study is now under way covering the relationship of the main conductor and the neutral conductor. This is a broad problem involving, first, the question of whether the neutral conductor should be at the top of the pole or underneath the main conductor and, second, the possibility of eliminating the neutral conductor altogether. Here, too, we follow the engineering procedure of first exhausting all analytical possibilities and then proceeding to rational testing.

Numerous new developments and inventions have been brought about in the course of the analytical study of short-circuit conditions. It was found that the so-called three-shot fuses can no longer be considered modern and that circuit breakers are required to take their place. A year ago there was only one type of sectionalizing breaker on the market. Three types are now being used experimentally, about 75 of each. About 3,000 of the older type of breakers were installed during the year and all reports indicate that they are

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Based upon an address presented at the fall meeting of the American Society of Agricultural Engineers, Chicago, Ill., December 3, 1941. The original address was prepared and presented before Pearl Harbor. Some of the developments predicted therefore have been delayed by subsequent restrictions on materials.

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contributing to the reduction of the number and duration of outages. It is reasonable to assume that within a short time the newer types of breakers will have established themselves on the market as standard articles.

Four REA projects are now equipped with carrier recording devices invented and developed by two young REA engineers and put into production by the Stewart-Warner Corporation. When a three-shot fuse or a sectionalizing breaker goes out a record is made instantaneously on a tape in the superintendent's office. Similarly, when service is restored, a record is made on the same tape. This tape not only gives immediate notice of failure and restoration, but also leaves a permanent record of all outages. It is hoped that within the next year 100 REA projects will be equipped with these devices.

Progress has been made in the development of two-way and three-way carrier communication over REA power lines. A "hot stick" has been built and tried out which makes it possible for a lineman to talk to headquarters from any place along the line by merely throwing the "hot stick" over the line. This has not yet been permanently installed anywhere, but it is hoped to equip three projects with this instrument experimentally very shortly.

The study of short-circuits and co-ordination of protective devices led to the conclusion that it is advisable to have circuit breakers instead of fuses in the farm homes. These circuit breakers must have certain definite characteristics to co-ordinate with the system. As a result, all new REA projects are equipping the farm homes with circuit breakers. In addition to better co-ordination of protection, it is an enormous convenience to the farm.

The problem of properly protecting a rural power system against short-circuits and lightning is by no means solved. There is no real protection for the primary side of a distribution transformer. But I feel optimistic enough to predict that very soon there will be a very small circuit breaker for this purpose, at a price not much higher than that of a fuse. I also feel optimistic enough to predict that soon there will be an automatic reclosing circuit breaker for the low-voltage side of the small distribution transformer, which will be sufficiently cheap for the purpose.

Industrial loads on REA lines have been growing by leaps and bounds and each industrial addition calls for a competent engineering analysis relating to voltage regulation and protection. As of January 1, 1941, there were reported 5,365 industrial and commercial consumers on REA lines, served by a total transformer capacity of over 106,000 kva. There is little doubt that the provision of electric power in areas where small industries are located filled a long-felt need. It is possible that a large proportion of these industrial loads did not exist or could not have existed prior to the availability of electric power. This survey shows clearly what has been accomplished in so short a time by spontaneous individual initiative in the way of decentralization of industry and stimulation of individual enterprise through the existence of a government-financed activity. It is a mere indication of what can be accomplished along the line of decentralization and migration of industries to rural areas with the attendant benefits both to the farm and to the industrial worker.

Another indication of the engineering problems involved in rural-electrification engineering is the enormous growth of energy used on the various REA projects. In 1939, REA systems purchased 152,398,000 kilowatt-hours for which they paid $1,843,962; in 1941, they bought 735,378,000 kilowatt-hours for $7,377,755. Thus, during the two-year period the increase in total kilowatt-hours purchased was not far from 400 per cent and the increase in money paid out was over 300 per cent.

Technical standardization without stagnation has been carried forward by REA successfully. The technical standards committees and their procedure, in the short time of their existence, have established an enviable reputation for themselves in the industry and in the engineering profession for competence, honesty, and progress. The record shows that as of November 1, 1941, the committees had cleared 598 items submitted by 68 manufacturers, unanimously approved 350 items, and unanimously rejected 83 items, the latter submitted by 23 manufacturers. Not a single complaint is on record. These committees are unique in governmental procedure.

Thus, within a short time rural-electrification engineering has become a respectable branch of engineering in general. It is hoped that from now on the engineering schools will begin to cover this branch in their courses and engineering societies will give it the time and space to which it is entitled.

ELECTROAGRICULTURAL ENGINEERING

Electroagricultural engineering may be defined as that branch of engineering which deals with the application of electricity on the farm. There is no evidence yet of even the beginning of a foundation of physics and mathematics for this branch of engineering. So far there is not yet in existence a crystallization of questions or a statement of problems in this field to be subjected to solution by engineering methods. There is hardly any competent accumulation of pertinent engineering data.

Some time ago it became evident that young men were leaving the farm and others were going into the army, throwing the burden of production on the women and the aged. It also became evident that the United States would have to feed a large army at home, other peoples' armies abroad, and, eventually, a good portion of the civilian population of Europe, Asia, and Africa. It was important to find out with how much less man power full production can be secured on an electrified farm than on an unelectrified farm. It was a great disappointment to discover that no adequate statistical data were available.

During the past year an effort has been made to secure from recognized authorities some pertinent statements on the relative importance of different durations of service interruptions of the several hundreds of possible applications of electricity on the farm. It was hoped that this would serve as a foundation for rationalizing the design of rural circuits. A list of some 300 items was prepared and sent out to six outstanding authorities in the field. It was thought that there would be a unanimous opinion in regard to many of the questions and that it would be possible to reduce the items calling for study to a relatively small number. But the six sets of answers show a bewildering diversity of opinion, even as related to items that might be considered self-evident. The great diversity certainly reveals the fact that no systematic study has ever been undertaken, but it is never too late to get started.

A visit to various agricultural colleges brought out the fact that many competent and serious-minded men, working under great handicaps, have developed some fine and useful equipment only to be discouraged because they could not interest any manufacturer to put it into production so that every farmer in the country could get the benefit of it. The best they could do was to send a set of prints or a booklet to the individual farmer and invite him to build it himself. However, if a farmer were to build himself all the gadgets for which instructions are sent to him, he would have little time for farming. But what else could those hard working, competent men of science do? The electric brooder will serve as a good illustration. At every agricultural college visited, someone had a new electric brooder which he considered superior to any other. Practically every agricultural engineer I met outside the colleges likewise had a new brooder, better than all others. In one of the colleges, when I was introduced to the professor, I asked him offhand to show me his new electric brooder. His surprised reply was: "How did you know that I had one?" Now each of these men has the welfare of the chicken sincerely at heart. Every one undoubtedly made some real worth-while improvement. All these improvements combined, should result in a range of standardized brooders that will meet practically all conditions. I do not mean that we then should stop improving. Every new automobile model has some improvements over the previous model. Yet we go ahead with quantity production without waiting for all possible improvements. When the time comes to go into production we say that other improvements will have to wait for the next model.

It is important that we have a clear picture of this bewildering and uneconomic situation. We must take the devices away from the inventors and place them into the hands of the manufacturers to be produced in quantity, so that they can be placed into the hands of every farmer. When I say "take them away" I do not mean that we should permit manufacturers to steal inventions and developments. On the contrary, it is of extreme importance that every research institution try to find some means of protecting the invention either for the benefit of the inventor or the institution. In either case it is important to make certain that the farmer will not be charged exorbitant prices.

Thus, both a new branch of engineering and a new industry will have to be created. Until now manufacturers could not be expected to spend money on new electrical developments to be used by individual small farmers. There was no ready market. But the situation has changed. With the hundreds of thousands of farms electrified in the last few years, with the group-purchase plan developed by REA which permits co-operative quantity purchases, a ready market is opening up for many new items for which no market was in sight a few years ago.

Those who have had experience in bringing out new ideas will realize that these new developments do not just happen. Every time anyone tries to bring out a new idea or a new device he encounters two kinds of opposition. First, there is the general inertia of the human mind. Most people do not like new ideas.

The other opposition consists of short-sighted manufacturers who try to force a customer to use what they make instead of making what the customer needs, or even anticipating and developing what he will need. However, a few manufacturers have had the courage to spend money on pioneering new developments, realizing that a new market is opening up and that specific equipment is needed for this market. In the long run, a big volume of business is bound to be their reward, and in some cases already is their reward.

Another important point is that in both rural electrification and electroagriculture we, in the REA, accomplished what we did without indulging in the luxury of establishing new research laboratories. We preferred to limit our own activity to invention and stimulation and to depend on all existing research facilities in colleges, governmental institutions, and manufacturing establishments to do the developing. This is more than any one laboratory, no matter how heavily endowed, could possibly do. The wisdom of this policy, I believe, is demonstrated by the fine results we had in such a short time.

Six years ago we had no rural electrification; today we have it. Even a year ago we had no electroagriculture; today we have the beginning of this new engineering. I feel that we are justified in hoping that, in spite of the efforts of some short-sighted manufacturers to force time backward, America still has enough progressive manufacturers that will soon bring out enough new devices to make the fully electrified American farm a reality.

Hand in hand with the development of this new industry, there must be an electroagricultural engineering on a foundation of physics and mathematics. No such thing is yet in existence. What is being done now is not yet engineering. It is not even a trade. It is more like the amateur age in radio. But, just as out of the amateurs in radio there eventually emerged a radio engineering and a radio industry, so it is hoped that out of the present amateur age of electroagriculture there will soon emerge a new electroagricultural engineering and a new electroagricultural industry.

REFERENCES

1. Suggestions and Procedures for Making a Sectionalizing Study, Technical Standards Bulletin No. 4, Rural Electrification Administration.

2. Inductive Co-ordination of REA Distribution Systems and Telephone Systems, **K. J. Plucknett, W. T. Smith, T. A. Taylor.** AIEE *Transactions*, volume 60, 1941, pages 586–95.

Vocational Education and the War

ALONZO G. GRACE

The recognized defects in the American system of public education will not be remedied by creating new agencies, but by the intelligent co-operation of educators and the public in the development of an educational program that will teach the citizens of the future how to live and how to earn a living, says a state commissioner of education, who points out that a trained citizenship is our first line of defense.

IT IS difficult in these trying days to comment on the long-term implications of education and in particular on the trends affecting vocational education. Our first thought necessarily must be directed toward the adjustment of an educational system to meet the requirements of total war; that is, the training of a labor supply, development of health and physical-fitness programs, translation of the war aims of the United States and the Allies into terms that can be understood by children and youth, the development of co-operative programs with the Army, the Navy, the Marines, Civil Aeronautics Administration, assistance in rationing procedures, enlightenment of the public with respect to the meaning of basic economic concepts, such as inflation, and a multitude of essential wartime activities.

One of Hitler's most powerful weapons is no secret weapon. His is an organization of a nation's youth—the mobilization of youth and its enthusiasm behind the supreme nationalist aim to restore the strength of Germany and to establish the Socialist State universally. Nazi organizations such as the *Jungvolk* (young folk), Hitler *Jugend* (Hitler youth), and *Bund Deutscher Maedel* (league of German girls) take in hand youngsters between the ages of 10 and 18. In the youth organizations these recruits are raised on Nazi propaganda and a thorough physical-fitness program. They are encouraged to become enthusiastic about sports, such as glider flying, model-airplane building, marksmanship, and the elementary principles of seamanship. They wear uniforms, go on long hikes, and learn to live in the open air. The first procedure in the totalitarian state has been a drastic reorganization of the educational system to provide the kind of members desired for the ultimate purpose of the state.

The American educational system is based upon a totally different idea. The control of educational opportunity in the United States is not centralized. The educational system is organized on a local basis, for in the United States the community is regarded as the cell of democracy. The importance of local initiative and responsibility is a matter not to be regarded lightly as we face the future. Through state leadership, service, research, and planning, with Federal financial assistance and leadership, and with local willingness to provide adjustments, a more effective educational opportunity is on the horizon.

With the understanding that the American school and college system is geared into the war effort, this article considers some reasons for educational lag, important trends affecting the future of vocational education, and some of the needs in the field of education generally.

SOME REASONS FOR EDUCATIONAL LAG

The school has been criticized for failure to produce a nation of skilled workers, for developing false ideals concerning the ultimate objective of living, for failure to develop good work habits in youth, and for many other reasons. It has become common practice to attribute many of our present difficulties to a faulty educational system. Granted that America has an unwieldy and ineffective system of local administrative organization; that many state departments of education do not exhibit inspiring leadership, acceptable scholarship, pertinent research, or effective service; that educators have been slow to face realistically the problems of youth; that the secondary-school program has been unduly academic in nature; that the school program is a series of unrelated

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Essential substance of an address presented at the AIEE North Eastern District meeting, Schenectady, N. Y., April 29–May 1, 1942.

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compartments; that these and many other criticisms of public education are just and valid—the remedy does not lie in the creation of other agencies to secure the needed changes. The best method of improving the school system and the best guarantee that the emerging product will represent social competency are to be found in the willingness of all elements to aid the existing educational system to perform the functions for which it was created. This is a major issue at the moment and no doubt will continue to challenge the disposition and vision of all concerned for some time to come.

There can be but one system of public education in the United States and that system should continue as it has for over 300 years—a responsibility of the several states, which with few exceptions delegate the actual conduct of the schools to the people of the state through local boards of education. The solution to our problem does not lie in a superstate or superfederal government that will absorb the functions of units closer to the people. While it may be admitted that many units of local government conceived during the pioneer era in the evolution of American democracy no longer are able independently and separately to provide all the services now required for the security of the people, the solution does not lie in the creation of or transfer to units far removed from the grass roots. Without the sustained interest of the governed, efficient administration and effective establishment of policy can be but partially attained.

Instead of attempting to place the responsibility for failure to avert many of our problems, our thoughts must be turned to the development of a constructive program. It is essential, therefore, that every state undertake the appraisal and evaluation of its own school system and that the wisdom and intelligence of its citizens and professional educators be used to the maximum in the development of a program that will teach people how to live as well as how to make a living.

Whatever be the lag in public education, it must be said that educators have not been wholly responsible. The following illustrate some of the factors involved:

1. *The Cost in Dollars and Cents.* It is cheaper in terms of dollars and cents for a school system to employ a teacher for 40 pupils in an academic course than to provide one teacher for 15 boys or girls who desire to learn a trade or to learn how to make a living.

2. *Parental Desire.* Many parents struggle throughout life in order that their children may not have to endure the hardship, the sacrifice, or unpleasantness that circumscribed their lives. False values have been placed on certain types of training.

3. *Prestige Value.* There is a prestige value attached to the college-preparatory curriculum that impedes the real job of education. The real weakness in public education emanates from the prevailing belief that other educational opportunities are devices designed to take care of those who indicate lack of interest, or fail, in the college-preparatory curriculum. If we would build a classless society, the social prestige attached to specific curriculums must be eliminated.

4. *Diplomas, Certificates, Degrees.* Business and industry have made the diploma from high school or college a prerequisite for employment. So long as those who employ regard the diploma of graduation as an index of competency, just so long will individuals fail to meet the requirements for employment. The criteria for employment should be "What can you do" and "How well can you do it" not "What kind of a diploma do you have" and "Where did you get it."

5. *Sacrifice and Work.* It is essential that the American people as a whole begin to feel a sense of sacrifice for the welfare of our country. Let us not believe that we can live without enduring hardships or that we can ease our way out of the trying situations confronting us. The utmost sacrifice will be necessary in the years to come if this nation survives.

Equal respect for all kinds of labor, physical and mental, honestly done, is recommended, but social barriers against the hand workers are set up. The office worker, for no good reason, is placed on a higher social level. This tendency must be corrected if there is to be a change in the school organization and curriculum. The best way would be to make honest statements concerning the qualifications of graduates.

We should be under no illusion concerning the training of the citizens of tomorrow. Vocational education and guidance do not create jobs. The proper diagnosis of the talents of the individual and the ability to ascertain those areas in which he can make the greatest contribution to his own happiness and to the security of society will at least give one a passport to a job. Training for the work of the world and for the work that each one is best able to do is the first essential in social security and the defense of a nation.

THE TRENDS AFFECTING VOCATIONAL EDUCATION

We cannot rest on the accomplishments of the past generation, in view of the conditions that will confront us during the next generation. Neither can we rest on the magnificent work of the present in the training of a labor supply for wartime industries. The accomplishments with respect to the broadening of the vocational program throughout America during this past generation are evident. We must secure a balance in our educational program that does not now prevail.

We are confronted with the need for continuous planning and action. There are evidences on the horizon toward which we must turn if we are to be guided in the proper direction. Some of the factors which will affect vocational education in the future are: declining school enrollment, the breakdown of the skilled trades into a series of jobs, the rapidly expanding apprenticeship program, the mass production of operators, the training-within-industry program of the War Production Board.

School Enrollment Declines. The statistical data on school enrollment have a distinct bearing on the future of vocational education. Frequently the objective of educational institutions may not be directed toward the welfare of the individual so much as toward protecting an enrollment. A qualitative criterion as the basis for operation has not been adopted generally. The facts revealed by the most recent available school enrollments are indicative of some of the problems. The following data illustrate the importance of the trend:

1. The total enrollment in United States public schools in 1928

was 25,179,696. The peak enrollment in 1934 was 26,434,193 pupils. A consistent decline has prevailed during the last eight years.

2. The elementary-school enrollment in 1928 was 21,268,417. This declined in ten years to 19,748,174, or 7 per cent.

3. High-school enrollment in 1928 was 3,911,275. It increased consistently to 6,226,934 in 1938, the peak year.

4. The enrollment in the first grade reached its peak with 4,171,037 in 1928. There was a consistent decline in the next ten years. Almost 900,000 boys and girls who should have been in the first grade if the trend of 1928 had continued are not there.

5. In 1918, 285,047 high-school and 27,915 college students graduated from their respective courses. Twenty years later there were 1,120,079 high-school graduates and 164,943 college graduates.

6. In 1870, there were only 16,000 graduates from high school out of 8,015,000 youth 17 years of age and over. In 1938, almost 46 out of every 100 youth 17 years of age graduated from high school. Of 2,458,000 of that age, 1,120,079 graduated.

7. There were in this country in 1938 21,049,000 boys and girls 5 to 13 years of age. By 1943, this group of 21,000,000 boys and girls will be 10 to 18 years of age. These are the youth who ultimately will determine the policies of this country.

The importance of these factors in the development of an educational program cannot be ignored. It is important therefore that as we reappraise and evaluate American education, a balance in our program be secured. There should be available to every boy and girl an opportunity to ascertain his or her fitness for occupations, to learn about the industrial and business resources of the country, to learn how to use his or her hands and talents to the maximum. These are needed as a balance to our highly academic procedure.

Breaking Down of Skilled Trades in the Job. The breaking down of the skilled trade into a series of jobs is no longer a matter of speculation. Because of the present crisis and America's past reluctance to train skilled workers, the desire on the part of many of our people to get out of anything that appears to be work, our failure to dignify work, and for a variety of other reasons, vocational education has not been as respectable as completing a college-preparatory course, so called. It was evident early, through the former Office of Production Management, that where skilled employees were not obtainable the engineer was called upon to reduce a given enterprise to a series of jobs in order to facilitate production. Thus much of the skilled work has been broken down into a series of operations suitably performed by semiskilled and in many cases by unskilled operators. There are many implications here both for labor and management as well as for training institutions. It is a trend that definitely cannot be ignored by educators. A long-delayed apprenticeship program now is under way. This is a basic essential in a complete educational opportunity. We have been without vision in delaying the growth of an apprenticeship program. This opportunity should provide for close integration with vocational schools or vocational opportunities within industry.

Job Training Does Not Produce Skilled Workers. There need be little comment on the purpose of the current training course for operators. It is designed to produce a labor supply rapidly. It is an induction into industry. It obviously does not produce skilled craftsmen. Too many youth, however, are under the impression that they are trained machinists as a result of having completed the work. This fact, together with exceedingly high wages for many youth who previously had earned little or had been on relief during the depression period, is producing a state of mind and an outlook with which there must be the utmost concern. Adjustments following the wartime effort will be extensive and severe.

SOME FUNDAMENTAL NEEDS

The transition in the secondary-school program will not be accomplished immediately. It is highly desirable that as changes are made full consideration be given to many important issues. The ability of all to think constructively and critically, rather than to accept without thinking the pronouncements of those with special interests, is fundamental in a democracy.

The very security of democracy itself is contingent upon the practical ability of the people to devise ways and means whereby all who desire to work may be provided with that opportunity. Men who own property and who have jobs are not the easy victims of subversive movements or of panaceas for their deliverance from a life of fear, want, unhappiness, joblessness, and lack of opportunity. Certain fundamental needs must be faced realistically. Only a few illustrations will be presented:

Work Should Be a Part of Education. Obviously, few people are interested in returning to the black page of yesterday when children labored long and hard. However, in our zeal to protect youth from the maturing value of work, we practically have made work itself a hazard. Certainly, the labor market should not be overcrowded by immature youth and adolescents. But the opportunity for every boy and girl, as part of education, to learn what hard work means—and that means manual labor, work with one's hands—must be reintroduced into our system. Work should be regarded as part of the educational program just as is Latin, mathematics, social science, or any other experience provided for the individual. In my judgment, with proper follow-up and supervision and recommendations from employers, it should receive credit on the high-school record and be accepted for college admission.

New Types of Colleges. It is obvious that the high-school program has been unduly academic in nature, though youth possess interest in other areas. Our colleges should provide admission based on the intellectual and social maturity of the individual and his capacity to read, write, and speak English. The procedure thus far is to gauge the student's competency or his desirability for college on his rank in the high-school graduating class and his capacity to pass certain specified courses.

Perhaps a difference in this respect should be made between the institution that specializes in the production of scholars and the institution of higher education that is dealing with average people. Those who have been the early and easy victims of subversive movements have been not only those without jobs and security, but many with insufficient schooling to enable them to distinguish between the forfeiture of their liberty and the panacea proposed for their deliverance. Too many young people fail in college; too many youth do not get to college because of economic inability of their parents. I believe then, that a system of scholarships should be made available to youth who because of economic incapacity ordinarily would be denied a college education.

The Search for Talent. I hope sometime in the United States we shall give scholarships or otherwise recognize the need for the development of ingenuity. Those who possess talent in any particular direction should be permitted to develop this talent to the utmost. I would hope, therefore, for the recognition of a system of education that would help perpetuate the ingenuity that has made our country famous. This means substantially that children should be permitted to develop to their greatest potentiality irrespective of race, nationality, economic condition, political affiliation, or any of the irrelevant factors that sometimes determine the future of the individual. Approximately as many competent youth are denied admission to college because of economic disability as enter because of parental ability to supply the financial means.

Determination of Fundamentals. Our secondary-school program generally represents a wide offering. Those subjects in the curriculum that are no longer of any particular use to large numbers of individuals should be eliminated. Fundamental changes ultimately may reduce the need for different subjects. This is particularly true if areas of experience supplant the narrow, subject-matter compartments. English, for example, should be taught as part of every course in the child's experience. The need for the specialist in speech, in reading, in the field of appreciation of literature is evident; so is the need for knowledge of arithmetic in high school.

Development of Marketable Skills and Aptitudes. The secondary school *may* develop in boys and girls marketable skills which will make employment much easier to secure upon completion of the 12th grade, or at such time as the individual may drop out of school. The further development of the program of arts and industries, beyond the present manual training or avocational approach; provision for review courses in arithmetic before leaving school; the concerted action of all teachers on such fundamentals as accuracy, neatness, thoroughness, ability to assume responsibility, willingness to follow directions, and many other qualities essential to employment—all these may be made possible in the comprehensive secondary school.

The Socially Competent Individual. It must be realized, too, that in the development of social competency the educational system as an institution or in co-operation with other institutions must provide sufficient opportunity for well-rounded development in several areas of life experience. Among the other areas are: (*a*) home and family life; (*b*) the socio-economic forces; (*c*) health; (*d*) ability to enjoy the aesthetic elements of life; (*e*) spiritual development of the individual; (*f*) natural environment; (*g*) training for work of the world with adequate provision for retraining opportunities.

These are trying times. It is altogether probable that many of the difficulties encountered during the period of the first World War may be repeated unless those in places of leadership are willing to face the situation realistically and without emotion. Plans must be well formulated. It is equally essential that there be recorded the almost universal desire on the part of our people for a better vocational opportunity for our youth. During ten years of a depression period, when many educators urged more vocational education and preparation for the days to come, few were willing to spend the additional sums to train the workers that ultimately were to be needed.

It seems to me that America should no longer hang its head or develop an inferiority complex. Our doctors no longer come from Vienna, our artists from Italy, our scholars from German or English universities. What have we to fear? It is in this country that the greatest inventive genius has developed. It is in this country that outstanding men of the medical profession, scientists, magnificent laboratories, tremendous research resources, and ingenuity unsurpassed anywhere in the world have evolved. We produce artists, musicians, skilled mechanics, as well trained as any in the world. We must provide greater opportunity for the discovery of talent. We must develop in our country an attitude toward work that will make graduation or completion of a vocational course of equal importance with graduation from an academic or college-preparatory course.

Men and women become citizens of the United States, and in that capacity determine the policies of democracy. Democracy is not safe until the people have been prepared to participate intelligently and rationally in the conduct of their own affairs. A constructive attitude toward government cannot be produced merely by waiting for it to develop. Let us remember this—each one of us is a citizen, whether he be a college graduate or possess merely a sixth-grade training. No one asks how much education a citizen has or what his intelligence quotient is when he casts his vote, runs for office, serves on a jury, or buys goods. The security of this country is vested in a trained citizenship. The first line of defense for the country is a citizenship prepared to do the work of the world; one that knows and is prepared to defend the things for which this country stands.

INSTITUTE ACTIVITIES

Vancouver Section Is Host to Its Fourth Pacific Coast Convention

The 27th AIEE Pacific Coast convention was held September 9–11 at the Hotel Vancouver in Vancouver, British Columbia. This was the fourth such meeting (1913, 1922, 1932, 1942) to be sponsored by the Vancouver Section since the program of approximately annual Pacific Coast conventions was initiated in 1910 under the sponsorship of the San Francisco Section. The recent meeting in Vancouver was the last national convention, as such, scheduled to be held by the Institute for the duration of the current war emergency, as the District and National technical meetings now being scheduled for future months will be devoted primarily to the discussion and interchange of information concerning technical developments and applications of especial significance in the war effort.

The several special features of the Vancouver program are reflected in the following report.

WAR NEEDS STRESSED

"Wartime National Efficiency" was the topic of a stimulating address given before a general dinner meeting on September 9, 1942, by G. A. Gaherty, president of the Montreal Engineering Company, Ltd., of Montreal, Que. Mr. Gaherty, briefly recounting significant aspects of the war, warned that:

"With all due respect for the splendid progress to date in the development of war materials and man-power resources, this is no time for complacency. We are facing a crafty and unscrupulous enemy. He has already cut us off from our main sources of three vital war materials—tin, tungsten, and rubber. He is taking a heavy toll of our shipping, and has played havoc with our lines of communication, notably his severing of the Mediterranean route to Suez. Our resources are being dissipated by convoying and by shipping via roundabout routes, by building ships to replace those he is sinking, and by constructing synthetic rubber plants. His resources, on the other hand, are increasing as he puts to work the enslaved peoples of Europe.

Analysis of Registration at 1942 Pacific Coast Convention

Classification	District 10	District 9	District 8	Miscellaneous	Totals
Members	72	32	13	5	122
Men guests	32	7	4	1	44
Women guests	30	24	7		61
Enrolled Students	3	4	11		18
Totals	137	67	35	6	245

"Make no mistake of it, victory can be achieved only by the complete mobilization of all resources, and their skillful employment in *offensive* operations, in other words, total war.... The great weakness of democracies is that their resources too often are frittered away through the deciding of war policies upon grounds of political expediency instead of military strategy...."

Mr. Gaherty's address is scheduled for early publication in *Electrical Engineering*.

INTERNATIONAL PREJUDICES DISCUSSED

Speaking on the topic, "International Prejudices," W. J. Gilson, General Manager of Eastern Power Devices, Ltd., of Toronto, Ont., presented much food for thought concerning the great need for international understanding and the simple and controllable circumstances that so frequently lead to international prejudices and misunderstandings. Experiences cited from his own far-flung career served admirably to give point to his general thesis that stable international relationship can grow only out of the intelligence and the conscious thought and effort of the individual.

Mr. Gilson spoke before a joint luncheon meeting sponsored by the Vancouver Electric Club. The substance of his address is given on pages 525–6 of this issue.

EXECUTIVE MEETING

A joint executive luncheon meeting was held September 9, 1942, by the Section and District officers of the Pacific area, with Vice-President C. A. Price of the Canadian District presiding. National Secretary Henline reported the recent action of the board of directors (EE, September 1942, page 477) whereby national and District meetings will be continued—but stripped of all social activities and with heavier technical programs—as a technical contribution to the war effort. The Institute's technical work and its facilities for the effective exchange of useful technical information, of recognized value and importance in peacetime, are potentially much more vital in wartime, and it is intended that every Section and every technical committee shall devote its efforts primarily to war problems. Sections are especially asked by President Osborne to devote at least one meeting to the conservation of critical materials. Sections also were asked at the summer convention to bend every effort toward facilitating and effectuating local scrap and salvage programs. Other matters of local interest were discussed.

Next year's Pacific Coast technical meeting is scheduled to be held in Salt Lake City under the auspices of the Utah Section.

TECHNICAL PROGRAM

As far as subject matter is concerned, electrical apparatus—ranging from relays to metallurgical furnaces—accounted for 7 of the total of 19 topics presented at 5 technical sessions. Wartime problems in power-system planning and operation were covered in six papers, and extensively discussed. Three papers dealt with industrial and operating experiences, principally in electrometallurgy, and three were concerned with circuits and electrical theory. The most active discussion concerned the operating and industrial topics.

Power-system interconnection for the interchange of power is nothing new in the electric-power industry. The Vancouver discussions, however, revealed great extension and refinement of methods of co-ordinated intersystem operation directed toward the wartime objective of getting the maximum total kilowatt-hour output from groups of power systems. As an example of the effectiveness of such efforts, effective firm-power generating-plant capacity in excess of 100,000 kw was reported salvaged among a group of systems, each of which operating alone was loaded to maximum firm-power capacity.

Discussion revealed that war-stimulation of electrometallurgical industries in the United States has brought the installed capacity of rectifiers serving these industries to a total of nearly 4,000,000 kw, with some 600,000 kw in additional capacity currently being added in the Pacific Northwest alone. For this service the steel-tank rectifier heavily predominates, especially in the United States, although the glass-bulb rectifier has strong support and is the feature of several large installations, especially in Canada.

STUDENT PROGRAM

Continuing a long-established custom with respect to Pacific Coast conventions, a part of the program was given over to the following group of technical papers prepared by members of various Student Branches in that area:

THE DESIGN AND CONSTRUCTION OF A 25-WATT HIGH-FIDELITY PUBLIC-ADDRESS SYSTEM, **R. E. Dye, R. C. Fortin**; University of Idaho Branch, Moscow, Idaho.

LIGHTNING AND BROADCAST TRANSMITTERS, **H. T. Stevinson**; University of Alberta Branch, Edmonton.

FREQUENCY RESPONSE OF RECORDING HEADS DETERMINED BY LIGHT-PATTERN MEASUREMENTS, **John Collins**; University of British Columbia Branch, Vancouver.

A STUDY OF THE EFFECT OF HIGH-FREQUENCY FIELDS ON MICROORGANISMS, **Hugh Fleming**; Oregon State College Branch, Corvallis.

NEEDLE-GAP-SPARKING VOLTAGE VARIATION AT LOW AIR PRESSURE, **W. J. McBride, R. H. Foy;** University of California Branch, Berkeley.

HEAT-FLOW STUDY BY ELECTRICAL ANALOGY, **Roger Brandt;** California Institute of Technology Branch, Pasadena.

LOW VOLTAGE BLACK-OUT ALARM AND SIGNAL SYSTEM, **A. H. Elliott;** University of British Columbia Branch, Vancouver.

ANALYSIS OF DISSIMILAR DELTA TRANSFORMER BANKS, **Glen E. Bredemeier;** Oregon State College Branch, Corvallis.

As the result of current conditions and the fact that many colleges were in essentially full operation, the total student attendance was somewhat lower than usual. Even so, there were present Student Branch chairmen or others representing 12 of the 15 Branches in the area, and counselors or other faculty representatives from 12.

Group meetings of the representatives present resulted in the selection of District officers as follows:

District 8, *chairman of student activities*—Professor F. W. Maxstadt, California Institute of Technology, Pasadena.

District 9, *chairman of student activities*—Professor R. E. Lindblom, University of Washington, Seattle.

At a luncheon conference of Student Branch representatives, counselors, and others interested, there were several brief addresses concerning various Institute activities and a general exchange of ideas concerning effective Branch activities. This conference was presided over by Vice-President E. W. Schilling of Bozeman, Montana. All 15 of the Student Branches in the Pacific area were represented by either the Counselor or the student chairman—9 by both. National Secretary H. H. Henline gave a brief outline of the present status and objectives of the Institute and its position with respect to other professional organizations. He called special attention to the action recently taken by the board of directors, directing the Institute's technical meetings and other activities primarily toward war problems. He mentioned also that 1942 is the fortieth anniversary of the initial steps to provide for Student Branches in the Institute's organizational structure. Editor G. R. Henninger explained the essential features of the Institute's present publication policy and procedure, whereby most technical papers and much other material of current importance reach each member promptly through the monthly issues of *Electrical Engineering*. Vice-President W. C. Smith of San Francisco spoke briefly on behalf of District 8, as likewise did Professor J. C. Clark of the University of Arizona, Tucson, who presented a summary of the Student Branch matters as discussed at the recent Summer convention in Chicago.

Pacific Coast Convention Registration—1932–1942

Year	Location	Registration
1942	**Vancouver, B. C.**	**245**
1941	Yellowstone Park	322
1940	Los Angeles, Calif.	465
1939	San Francisco, Calif.	*
1938	Portland, Ore.	454
1937	Spokane, Wash.	266
1936	Pasadena, Calif.	*
1935	Seattle, Wash.	269
1934	Salt Lake City, Utah	232
1933	(No Pacific Coast convention)	
1932	Vancouver, B. C.	300

* Combined with summer convention.

ENTERTAINMENT AND SPORTS

Principal feature of the war-limited social program was the 22d annual competition for the John B. Fisken cup. This year's winner was Bernard De M. Mertens (A'14, M'25) of the British Columbia Electric Railway Company, Ltd., Vancouver (Vancouver Section), whose low net score of 71 was achieved by a gross total of 85 and handicap of 14. Runner-up was J. C. Henkle (M'36) of the Portland (Oreg.) General Electric Company (Portland Section) (82−8=74 net). The low gross score of 80 was made by J. W. Butler (A'31, M'38) of the General Electric Company, Schenectady, N. Y. (Schenectady Section). E. G. Cullwick (A'26, M'33) of the University of Alberta (Edmonton Section), Edmonton, was runner-up, with a score of 83.

The Fisken trophy is a Pacific Coast institution, only active members of the Los Angeles, San Francisco, Salt Lake City, Spokane, Portland, Seattle, and Vancouver Sections being eligible for competition. Custody of the cup for one year, and the engraving of the winner's name on the cup is the coveted privilege of winner of low-net score. John B. Fisken himself presented the trophy to Mr. Mertens at a joint luncheon sponsored by the Vancouver Electric Club.

Other social features included a luncheon party, musical program, and a bridge-tea for women guests, and a formal dance for all those attending the meeting.

"International Prejudices" Discussed at Vancouver

Great oaks of international misunderstanding grow from little acorns of individual—and usually ill-founded—prejudice. Such in essence was the theme of a thought-provoking address given at the Pacific Coast convention, September 9–11, 1942, in Vancouver, B. C., by W. J. Gilson (A'26, M'38), general manager of Eastern Power Devices, Ltd., of Toronto, Ont. The occasion was a joint luncheon sponsored by the Vancouver Electric Club. The essential substance of Mr. Gilson's address follows.

EMOTION VERSUS INFORMATION

I recently commenced reading a rather lengthy book entitled "War and Peace" by the famous Russian author Leo Tolstoy. In the preface inserted by the publisher, the reviewer, Clifton Fadiman, states that Tolstoy intently studied individuals in a small group, and then integrated their behavior into group behavior in order to try to analyze the laws of history. Now, this is not a new thought by any means. In electrical engineering we use precisely the same method of diagnosing performance on a large system, by studying the behavior of a small circuit of known dimensions.

I wish to stress this method of logical appraisal. Study your own hearts and appetites and desires, and then study the group of people with whom you come into daily contact. Then try to integrate this group into one common channel of well-defined approach towards the truly democratic and Christian way of life about which we hear so much. I think if you are observant, reasonably dispassionate, and honest, you will be forced to make the channel a very broad one to take care of the harmonics. (But a common channel can be found if one is ready and willing to accept the law of averages.) This is the keynote to the existence of prejudice, both local and civic, religious and political, national and international.

Most of us are not willing to consider our own deficiencies when contemplating those of others. We become irritated when people of other religious, political, or racial groups express views which appear at variance with our own. We talk freely about democracy and Christianity, but we do not significantly appraise or try to control the steady betrayal of these principles by a certain percentage of people in each group and community. Ignorance, fear, and emotionalism, which form the prime ingredients for predjudice, unfortunately are not confined to the uneducated or poorly educated people. They stalk through every branch of human society from the bottom to the top, and are virtually unchecked except by the almost imperceptible upward movement in the progress of human intelligence through the ages.

Dare I mention the wave of bitterness and prejudice which was so abundantly in evidence in a certain large republic on the American continent during a presidential election in 1940? Sharp intolerance and rampant prejudice were running wild on a wave of pure emotionalism. Some people emerge from such a delirium as they would from the aftermath of a college football final, but many allow their intolerance to harden and their sense of proportion is then permanently out of order. These are the people who create the Hitlers and Mussolinis.

My interest in the international viewpoint started as a boy of fourteen and was not altogether a voluntary procedure. I received my early education in a little country school in northern California, and in due course learned all about the Revolutionary War. At age 14 I was sent to school in England, and I found that the English boys had an entirely different conception of the Revolutionary War, and were just as sure of their ground as I was. They also gave me some supplementary data about which I knew nothing, and which placed me somewhat at a disadvantage. I learned of the British preoccupation with the French during this period, and also that the British Parliament was sharply divided in its support of the attempt to suppress the American Revolution. The records of speeches made by the Opposition leader, William Pitt, to the House of Parliament on this subject stand as undeniable testimony of free speech and liberal thinking in England, even in those days.

To the American schoolboy the Revolutionary War was a number one man-sized affair crowned by victory. To the British schoolboy, that colonial affair was an unfortunate family squabble which was handled very indifferently because of other more pressing events closer to home.

CONSIDER AVERAGES, NOT INDIVIDUALS

I was aggressively certain at that time that any full-grown American could lick five wild cats bare-handed. The English boys seemed very unimpressed. Maybe they weren't so sure about the five wild cats, but they were quite certain that any Englishman was immeasurably superior to any other adult species of homo sapiens not indigenous to the sovereign domain of England. I fought many a bitter scrap to prove my point, and with a fair degree of physical success, but it gradually dawned upon me that bloody noses and bruises didn't seem to have any influence on the psychological problem. I also found out over a period of time that some of these English boys were ace-high and presumably their fathers were before them, and so I received my first lesson about the law of averages.

Later on, World War I broke out, and in 1915 at the age of 17 I joined the British Army. During this war period, with troops of different nations constantly intermingling—English, French, Irish, Scottish, Canadian, Australian, American, Portuguese, and Belgian—I was keenly interested in noting that there was a small percentage in each group with which I came into contact who appeared to be roused easily to antagonism against one, or more, or perhaps all other national groups. They were only a small percentage, but they very often influenced their fellow nationals to quite a degree. While I appreciate how dangerous it is to generalize, in summing up my experiences and observations in later years I decided that most of the individuals in these groups, regardless of nationality, had characteristics very much in common. For the most part they were what I now term 100-per-centers. They were 100 per cent English, or 100 per cent American, or 100 per cent French, and they are still with us. These 100-per-centers have never heard of the law of averages, they have no conception of tolerance. You either belong to their group and talk their language, or you just don't rate. Further than that, if you dare to suggest that it is slightly illogical to cleave the whole world into one small group, all white, and to consider all the rest black, you are in for either cold disdain or a white-hot tongue lashing.

BEWARE THE 100-PER-CENTER

It is of course true that these 100-per-centers perform a great deal of valuable work during war periods because their high pitch of emotional behaviorism is very closely associated with that all-important spirit called morale. Nevertheless they are also at the root of most of our international pitfalls and prejudices. Hitler undoubtedly is a 100-per-center and so are all his cohorts.

All national groups have different viewpoints on many things, and also at least slightly different standards of values, both moral and physical. Somewhere through the middle runs an average to which we all probably could subscribe without much national loss or gain. But it is usually on these small differences that misunderstandings arise and grossly unfair, sweeping judgments are made.

For example, there is a fundamental difference in the attitude of the British and that of the people of the North American continent toward sports. This also was part of my early education in learning to appraise people on the basis of the law of averages.

In England, football, cricket, badminton, and even boxing are faintly reminiscent of the "ye goode olde days" we read about when knights in shining armor went forth to show that they could "take it" and be jolly good sports even with a cracked pate. The English crowd likes the finesse of the game and an occasional sample of giving the other fellow a break. They can be more enthusiastic over a good loser than a winner who appears to disregard their finely drawn sporting code. Here in the United States, in football, baseball, hockey, boxing, and other sports, the whole technique is the essentially simple one of playing to win. There is no reason why people in either country should feel that their viewpoint is right and the other viewpoint wrong. Both are reflections of perfectly accidental habits which have followed different patterns.

For a short time in 1921 I worked at a sugar refinery in Crockett, California. One of my work mates there, who hailed from San Francisco, had served as a top sergeant with one of the United States regiments in France. He was a typical 100-per-center. The United States had won the war—the French were so-and-so's who played the United States for suckers—and the British—nothing was too bad to say about the British. Yes sir, he had been in England and sized them up for himself. I got him alone one day deliberately to ply him with a few questions, and this is what I learned. He told me that his father had been born in England, and that he had always thought England and the English were O.K., until he went there. He had spent a ten-day furlough in England just before returning to the United States after the Armistice. The ten days were spent in cheap hotels in London and Liverpool. He had seen nothing at all of the charming English rural towns. He had met no decent English families, but had been in a riotous free-for-all in one of the Liverpool pubs or beer parlors, and later on had his wallet stolen. That was the sum of his contact with England and the English, and on such flimsy, fleeting, misguided experiences he summarily condemned a nation. On such comparatively minor differences and misunderstandings are international prejudices and enmities created.

Returning to this question of individual intolerance integrated into group behavior, I wish to stress again the damage done to broad understanding and intergroup or international harmony by these people I term 100-per-centers. To be 100-per-cent behind any temporary action such as the present war (which we hope *is* temporary) or a sports movement, or even an AIEE convention is necessary for practical purposes and is logically sound. However, to be 100-per-cent behind any group movement which tends to set up exclusive standards for one chosen clique or race is obviously wrong, and downright insulting to those in other groups. In a sociological sense one cannot be 100-per-cent anything unless one is 100-per-cent for humanity as a whole. If this is not true, then the fundamental basis of our Christian way of life reeks with hypocrisy and is absolutely rotten to the core.

EMOTION VERSUS LOGIC

In order to avoid any misunderstanding, let me state a belief that it is not necessary, in fact it is downright dangerous, to work up emotional peaks on alleged racial superiority even during a war period. There was nothing emotional about any first-class boxer I ever met, at least not with respect to his job of scientifically beating up some opponent. In fact, in boxing one is trained deliberately to develop the detached viewpoint because emotional disturbances not only cause faulty judgment, but also burn up too much reserve energy. The fact that a good boxer does not hate his opponent or think he's an inferior beast does not hinder the boxer from doing a first-class job of pounding the daylights out of his opponent, if he is able to do so.

In this war, we have a job of severe corporal punishment to mete out against those foreign 100-per-centers who have led their groups and races by the nose through their fanaticism. This short-term trend, however, does not relieve any of us from our share in the common problems of world humanity when we finish smashing the gangster gangs.

"Calculation of Fault Currents" Available in Reprint Form

The report, "Simplified Calculation of Fault Currents," prepared by the AIEE committee on protective devices, which appears on pages 509–11of this issue, is being made available in reprint form. The subject is of widespread interest and it is believed that Institute members and others may wish to have reprint copies for convenient reference. The report may be obtained from AIEE headquarters, 33 West 39th Street, New York, N. Y., at 15 cents per copy with a 20 per cent discount allowed on ten or more copies sent to the same address at the same time. Quantity prices will be quoted on application.

"Conservation Through Good Engineering" Is Technical Program Theme

"Conservation Through Good Engineering" is the wartime theme adopted as a basis for AIEE technical programs in the immediate future. This action was taken by the AIEE technical program committee at its meeting held September 18, 1942, at national headquarters in New York City, in accordance with the new AIEE Wartime Policies as defined and reported on page 477 of the recent September issue of *Electrical Engineering*.

Under this program each technical committee, so far as possible, will review its existing standards and methods of application of electrical apparatus, recommendations of the National Electrical Manufacturers Association and the War Production Board for the closer selection or maximum safe loading of apparatus; and will prepare "guides" or "general principles" similar to the transformer subcommittee report (42-156), published beginning page 692 of the *Transactions* section of the September 1942 issue of *Electrical Engineering*.

ADHERE TO BASIC STANDARDS

These guides will serve a double purpose. First, they will educate users to apply equipment more closely and to lay out systems in such a way as to conserve copper and other strategically important materials. Secondly, they will serve to educate users in the more diverse application of standard apparatus, through showing how apparatus will perform under widely varying conditions, and what the maximum limits of safe application are. It is believed that the existing AIEE and American Standards are fundamentally sound, so that the war objective will be far better served by educating users to apply standard equipment more closely, than by any possible revisions of the Standards themselves.

The technical program committee believes that through the preparation of these committee reports the Institute can perform a very useful service in the war effort. While the list of topics to be covered is not final, the accompanying tabulation of nine subjects definitely has been undertaken by the committees indicated.

REPORTS TO BE AVAILABLE FOR LOCAL DISCUSSION

As rapidly as they are completed, these reports will be available for discussion at Section meetings and at national, and District technical meetings. It is hoped that in many cases Section meetings may be arranged jointly with other engineering groups, or in co-operation with the War Production Board, so that the recommendations in these committee reports may be put to the best possible local use.

With reference to the national program to reduce waste through fires, as reported on page 493 of the September issue, Institute technical committees plan to give particular attention in the preparation of these reports and elsewhere to methods and practices that will reduce the risk of electrical fires.

Proposed AIEE "Guides (or Principles) for the Selection and Operation of Electric Equipment"

To Be Prepared by Technical Committees, not Later Than January 1, 1943, if Possible

Topic	Sponsoring Committee and Chairman
Report Already Published	
Interim Report on Guides for Overloading Transformers and Voltage Regulators; AIEE Paper 42-156; 15 cents by mail	Transformer subcommittee, committee on electrical machinery, M. S. Oldacre, chairman
Reports Under Preparation	
Distribution transformers and voltage regulators	Transformer subcommittee, committee on electrical machinery, M. S. Oldacre, chairman
Switchgear	Committee on protective devices, T. G. LeClair, chairman
Current capacities of bare conductors	Committee on power transmission and distribution, Philip Sporn, chairman
Low-voltage insulated cables	Committee on power transmission and distribution, Philip Sporn, chairman
Supply of rkva (or kilovars) on distribution systems	Committee on power transmission and distribution, Philip Sporn, chairman
Industrial power-distribution systems	Committee on industrial power applications, J. J. Orr, chairman
General purpose motors and controls	Committee on electrical machinery, F. E. Harrell, chairman
Power-generating equipment	Committee on power generation, A. C. Monteith, chairman

Future AIEE Meetings

National Technical Meeting
New York, N. Y., January 25–29, 1943

District Technical Meeting
Providence, R. I., April 7–9, 1943

District Technical Meeting
Kansas City, Mo., April 28–30, 1943

National Technical Meeting
Cleveland, Ohio, June 21–25, 1943

STANDARDS . . .

The following AIEE standards may be obtained from AIEE headquarters, 33 West 39th Street, New York, N. Y., at the prices specified. A 50 per cent discount is allowed to AIEE members on single copies.

Apparatus Bushings. This standard (No. 21) which includes as an appendix the "Test Code for Apparatus Bushings" was approved by the board of directors on June 24, 1942. It has been available in report form since March 1941. The standards specifically cover the following types of bushings: (a) outdoor bushings for large apparatus; (b) cover-type bushings for small apparatus; (c) indoor bushings for all types of apparatus except dry-type instrument transformers, air-blast transformers, dry-type regulators, circuit breakers rated below 5,000 volts, and nonoiltight oil circuit breakers rated 50,000 kva or less. These standards are not intended to apply to wall bushings, cable potheads, or insulators for back-connected disconnecting switches, although many of the principles may be applicable. The bushing requirements as specified in these standards apply to bushings when mounted for testing in accordance with specified arrangements as given in the Test Code—Appendix I. (40 cents.)

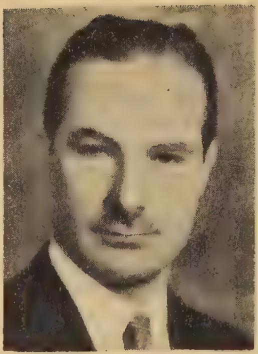
Air Switches and Bus Supports. This revised standard (No. 22) approved by the board of directors June 24, 1942, supersedes the former standard of the same title which was approved for a trial period of approximately one year. The standard covers all types of air switches and bus supports above 600 volts whether for indoor or outdoor service. It does not apply to air circuit breakers covered by standard No. 20. (40 cents.)

Switchgear Assemblies. This revised standard (No. 27) approved by the board of directors August 7, 1942, supersedes the former "Standard for Switchboard and Switching Equipment for Power and Light" (No. 27) of October 1930, and its proposed revision "Switchgear Assemblies" (No. 27A) of March 1941. These standards cover assemblies of switchgear devices such as switches, interrupting devices, control, metering, protective and regulating equipment with associated interconnections and supporting structures. These standards do not apply to industrial control equipment, communication switchboards, switching equipment, or switchboards for shipboard. (30 cents.)

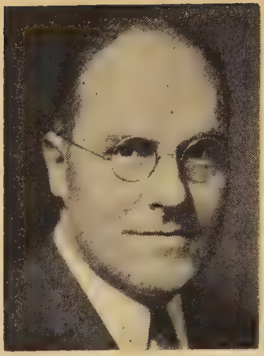
Guiding Principles for the Selection of Reference Values for Electrical Standards. This pamphlet (No. 3), a proposed standard approved for a trial period of approximately one year, is designed to serve as a guide in the preparation or revision of standards for apparatus or materials of specific types or fields of use. If a particular existing standard calls for other provisions, the existing standard should be followed. The values given are not mandatory, but are recommended for use in preference to other values unless there are good technical or economic reasons for using others. The values recommended have in general been selected to agree with well established practices. Provisions are made for a great variety of conditions and for widely different apparatus and materials, some of which may be of practical importance only under unusual circumstances. (No charge.)

Neutral Grounding Devices. This pamphlet (No. 32) is a proposed standard approved for trial use, which applies to grounding transformers, and to resistors, reactors, capacitors, and combinations of these, when used for grounding the neutrals of a-c electric systems. (No charge.)

PERSONAL • • • •



G. Ross Henninger



D. C. Prince

C. R. Beardsley

G. Ross Henninger (A'22, M'27), AIEE editor since 1933, has been granted leave of absence to accept a commission as lieutenant colonel in the Army Specialist Corps. He will serve as liaison officer on the headquarters staff of the Corps at Washington, D. C. He was born in Hamilton, Ohio, May 22, 1898; attended the public schools of Ocean Park, Venice, and Santa Monica, Calif.; received the degree of bachelor of science in electrical engineering from the University of Southern California, Los Angeles, with the class of 1922, after completion of extracurricular work in the fields of civil engineering and business administration. During his university career he was a full-time employee of the Southern California Edison Company, Ltd., serving in the company's operating department as a substation and powerhouse night-shift operator. Upon graduation, he entered the student course of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., subsequently becoming a member of the relay section of the company's supply engineering department where he spent a year in laboratory, office, and field work. Leaving the employ of the Westinghouse company, Mr. Henninger re-entered the services of the Edison Company in 1923 as operating assistant to the electrical protection engineer, in which position he was charged with responsibility for the satisfactory operation of protective relay equipment throughout the company's system. In 1924, he left the Edison company and moved to San Francisco to become engineering editor of the then *Journal of Electricity* (which subsequently changed its name to *Electrical West*) the Pacific Coast publication of the McGraw-Hill Publishing Company, Inc. In that position he developed and was in responsible charge of the technical department of the magazine until he went to New York in 1930 as associate editor for the AIEE. He remained in the latter position until he was named editor in 1933. In addition to his duties at AIEE headquarters, he devoted a substantial amount of his time from January to June 1942, to the United States Navy Department, in Washington, in the organization of an editorial and review section for the co-ordination of Navy technical material. Mr. Henninger had been active in Institute affairs for many years prior to his employment on headquarters staff. He was one of the organizers and was first chairman (1921) of the Student Branch at the University of Southern California; he served on various Pacific Coast convention committees (1925–30); served the San Francisco Section successively as member of the executive committee, secretary, and vice-chairman. During his employment by the Institute, he has served in various capacities in activities carried on jointly by AIEE and other societies, including: publicity committee, American Engineering Council (1937–40); information committee, Engineers Council for Professional Development since 1934 (chairman 1941–42). Mr. Henninger also has been active in civic affairs in his home community, having served as vice-president, Teaneck, N. J., Taxpayers League, 1934–36; trustee, Haworth, N. J., Municipal Library since 1936; member of the Haworth Board of Education since 1940 (currently president). He is also a member of the Society for the Promotion of Engineering Education.

D. C. Prince (A'16, F'26) vice-president in charge of application engineering, apparatus department, General Electric Company, Schenectady, N. Y., has been appointed chairman of the AIEE committee on planning and co-ordination for 1942–43. He was born February 5, 1891, at Springfield, Ill., and was graduated from the University of Illinois with the degrees of bachelor of science (1912) and master of science (1913) in electrical engineering. In 1913 he entered the test course of General Electric Company at Schenectady. From 1914 to 1917 he was employed on valuations and ratemaking by the Illinois State Public Utilities Commission, and from 1917 to 1919 he served in the United States Army. He returned to the General Electric Company in 1919 and the following year was appointed a research engineer in the radio department. In 1923 he was assigned to the research laboratory, first to work on vacuum-tube applications and later on power control. He was transferred to Philadelphia in 1929 as research engineer of the switchgear department, becoming chief engineer in 1931. He served in this capacity until 1940, when be became manager of commercial engineering for the General Electric Company in Schenectady. In 1941 came his appointment to his present position. Mr. Prince is a past president (1941–42) of the Institute. He was a member of the board of directors (1938–41) and the board of examiners (1938–40), and has been a member of the Charles A. Coffin Fellowship and Research Fund, the Charles LeGeyt Fortescue Fellowship, Lamme Medal, Edison Medal, and finance committees and the committees on transfers, protective devices, and air transportation. He has been AIEE representative on the John Fritz Medal Board of Awards since 1941, and at present is serving as AIEE representative on the Engineering Societies' 1942–43 joint committee on postwar planning. He is the author of many technical papers and articles, is co-author of two books, and holder of a number of patents. He was honored in 1939 as a "modern pioneer" by the National Association of Manufacturers. He also is a member of Eta Kappa Nu, Tau Beta Pi, and Sigma Xi.

C. R. Beardsley (A'08, F'30) has been appointed chairman of the AIEE special committee on registration of engineers for 1942–43. He is on wartime leave of absence from Consolidated Edison Company of New York (N. Y.), Inc. to act as assistant to the commissioner of the Department of Commerce of the City of New York, and is engaged in war-production problems in the Greater New York area. Mr. Beardsley was born December 19, 1885, in Bridgeport, Conn., and was graduated from Yale University in 1905 with the degree of bachelor of philosophy in electrical engineering. From 1905 to 1911 he served in various capacities with the General Electric Company, Schenectady, N. Y. and New Haven, Conn., and in 1911 became sales agent in charge of layouts and industrial distribution. In 1918 he joined Fred T. Ley and Company, Springfield, Mass., as electrical engineer in charge of design and installation of power stations. In 1923 he became electrical construction engineer with Brooklyn (N. Y.) Edison Company, and was successively appointed assistant to superintendent of distribution (1932) and superintendent of distribution (1934). He was transferred to the Consolidated Edison Company in 1938, was made manager of the contract control and inspection department in 1939, and associate manager of station construction and shops in 1942. Mr. Beardsley was a member of the AIEE board of directors (1937–41), and was chairman of the New York Section (1935–36). He was chairman of the special committee on model registration law (1937–39), until its functions were taken over by the committee on legislation affecting the engineering profession, of which he was chairman (1939–41). He also has been a member of the Edison Medal and technical program committees and the committee on institute policy. He is currently serving as AIEE representative on the National Bureau of Engineering Registration and as a member of the AIEE committee on code of principles of professional conduct. He is the author of many technical papers.

Robin Beach (A'15, F'35) professor and head of the electrical engineering department, Polytechnic Institute of Brooklyn (N. Y.), has been appointed chairman of the AIEE committee on education for 1942–43. He has served on that committee since 1935. He was born at Robin's Island, Long Island, N. Y., August 30, 1889, and received the degrees of bachelor of science in electrical engineering (1913) and electrical engineer (1922) from the University of New Hampshire, and master of science in physics (1922) from New York University. In 1913 he served as an instructor in engineering drawing and descriptive geometry at the University of Illinois, Urbana, and in 1914 became assistant professor of electrical engineering at Texas Agricultural and Mechanical College, College Station. In 1917 he was appointed head of the department of electrical engineering at Norwich University, Norwich, Vt., and the following year was appointed to the electrical engineering faculty of the Brooklyn Polytechnic Institute as associate professor. In 1927 he received his full professorship and in 1930 was appointed head of the department of electrical engineering. In addition, he also served as educational director for the Brooklyn (N. Y.) Edison Company from 1922 to 1933. Professor Beach has been a member of the AIEE committee on production and application of light since 1935 (chairman 1937–38), and previously served on the same committee during 1933–34. He has been AIEE representative on the United States national committee on the International Commission on Illumination since 1937, and is currently serving on the standards and technical program committees. He is a member of the Society for the Promotion of Engineering Education, and is also a member of Eta Kappa Nu and Tau Beta Pi.

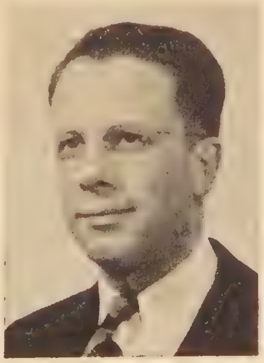
T. F. Barton (A'12, F'30) commercial vice-president and district manager, General Electric Company, New York, N. Y., has been appointed chairman of the AIEE finance committee for 1942–43. He has been a member of the finance and executive committees since 1939, and also has served on the membership committee, the committee on transfers, and the board of examiners. He was chairman of the AIEE New York Section in 1932–33, a vice-president in 1939–40, and is serving currently as a director of the Institute. He was chairman of the committee on legislation affecting the engineering profession (1935–37), and has been also a member of the committees on the economic status of the engineer and industrial power applications. At present he is a member of the Edison Medal and headquarters committees, and the committee on planning and co-ordination. Mr. Barton was born December 25, 1887, at Rowesville, Orangeburg County, S. C., and received from Clemson College the degree of bachelor of science in electrical engineering in 1906. He entered the testing department of General Electric Company, Schenectady, N. Y., in 1906, and in 1909 was transferred to the d-c engineering department. He served in the engineering department of the New York office from 1911 to 1917, when he returned to Schenectady as a section head in the central-station engineering department. He became district engineer of the New York district in 1927, assistant manager of the New York district in 1939, and in 1940 was appointed to his present position. Mr. Barton has twice won Charles A. Coffin Foundation awards for contributions to the electrical industry.

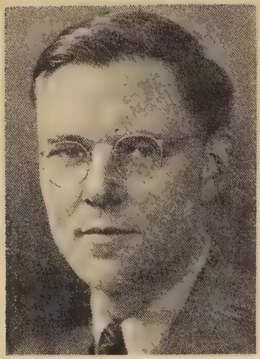
J. R. North (A'21, F'41) assistant electrical engineer, Commonwealth and Southern Corporation, Jackson, Mich., has been appointed chairman of the AIEE standards committee for the year 1942–43. He has served on this committee since 1941. He was born in Cambridge, Mass., February 20, 1900, and received the degree of bachelor of science in electrical engineering at California Institute of Technology in 1923. He was a substation operator for the Southern California Edison Company, Los Angeles, Calif., 1920–23, and during 1922–23 was an assistant instructor in electrical engineering, California Institute of Technology, Pasadena. He was a student engineer with the Westinghouse Electric and Manufacturing Company at East Pittsburgh and Sharon, Pa., during 1923–24. Since 1924 he has been associated with Commonwealth and Southern Corporation and its predecessors, first as engineer in the investigation division, then as assistant investigation engineer (1927), and general technical engineer (1931). He has held his present position since 1939. Mr. North was chairman of the AIEE Michigan Section in 1934–35, and has been a member of the technical program committee and the committees on protective devices, electrical machinery, and the economic status of the engineer. He is serving at present on the Institute's committee on planning and co-ordination, and is AIEE representative on the electrical standards committee of the American Standards Association, and on the United States National Committee of the International Electrotechnical Commission. He is also a member of the Edison Electric Institute and Tau Beta Pi.

H. A. Kidder (A'06, F'29) retired superintendent of motive power, the Interborough Rapid Transit division of the New York City (N. Y.) Transit System, has joined the Chemical Construction Company, New York, N. Y., as assistant to the general supervisor of plant operation. He is in charge of the operation of power plants. Mr. Kidder entered the student course of the General Electric Company, Schenectady, N. Y., in 1903, and spent

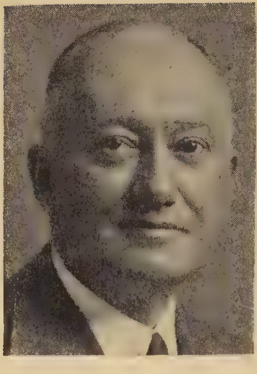
Robin Beach

T. F. Barton


J. R. North

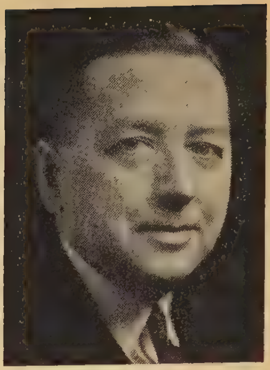


H. H. Race



E. T. Mahood

T. G. LeClair



S. B. Williams

three years in the testing department. In 1906 he was transferred for a brief period to the railway motor department, and subsequently became associated with the Interborough Rapid Transit Company as assistant electrical superintendent. He was successively appointed electrical superintendent (1914), assistant superintendent of motive power (1920), and superintendent of motive power (1921), a position he held until his retirement in June, 1942. He has served as chairman of the AIEE headquarters (1925–26) and finance (1926–28) committees, and chairman of the committees on co-ordination of institute activities (1928–30), the engineering profession (1929–31), and legislation affecting the engineering profession (1931–32). He was a member of the executive committee (1926–30) and the board of examiners (1930–40), and has served on various technical and special committees.

H. H. Race (A'24, F'39) research engineer, General Electric Company, Schenectady, N. Y., has been appointed chairman of the AIEE technical committee on basic sciences for 1942–43. He has served on that committee since 1933. He was born February 12, 1899, in Buffalo, N. Y., and was graduated with the degrees of electrical engineer (1922) and doctor of philosophy (1927) from Cornell University. He was a student instructor in electrical engineering laboratory at Cornell University (1920–22), and in 1922 he became a design engineer in the transmission and distribution department of the Philadelphia (Pa.) Electric Company. He returned to Cornell University in 1923 to serve as instructor in advanced technical theory, becoming assistant professor in 1927. He was placed in charge of courses in junior electrical theory in 1928. He joined the research laboratories of the General Electric Company, Schenectady, N. Y., in 1929 as a research engineer, directing projects on electrical properties of liquid and solid insulating materials. In 1928 he was awarded the National and North Eastern District prizes for an initial paper. He was chairman of the AIEE sections committee (1938–40), and has been a member of the research and publication committees, and the committee on planning and co-ordination. He is currently serving on the standards, technical program, and publication committees. He is the author of a number of technical articles and papers. Doctor Race is a member of the American Physical Society, American Association for the advancement of Science, and the National Research Council, as well as Eta Kappa Nu, Sigma Xi, and Tau Beta Pi.

E. T. Mahood (A'26, F'36) engineer, Southwestern Bell Telephone Company, Kansas City, Mo., has been appointed chairman of the AIEE sections committee for 1942–43. He has served on that committee since 1936. Mr. Mahood was born in St. Louis, Mo., August 3, 1887, and was employed by the Bell Telephone Company, St. Louis, Mo., in 1904 as a draftsman. He has been employed continuously in telephone plant and engineering work by this company and its successors since then. He was made district plant engineer in Wichita, Kans., in 1911, division plant engineer in Little Rock, Ark., in 1912, and plant engineer in Topeka, Kans., in 1917. He was transferred to St. Louis, Mo., as valuation engineer in 1919. In 1926 he became engineer in charge of the Western Missouri and Kansas area, Southwestern Bell Telephone Company. Mr. Mahood is a past chairman of the Kansas City Section (1935–36), and is serving now as AIEE vice-president representing District 7. He is serving also as a member of the committees on communication and on planning and co-ordination.

T. G. LeClair (A'24, F'40) supervising development engineer, Commonwealth Edison Company, Chicago, Ill., has been appointed chairman of the AIEE committee on protective devices for the year 1942–43. He has served on that committee since 1931. He was born at Superior, Wis., August 26, 1899, and was graduated from the University of Idaho in 1921 with the degree of bachelor of science in electrical engineering. In 1922 he was a student engineer with General Electric Company, Schenectady, N. Y., and entered the employ of Commonwealth Edison Company in 1923 as a cable engineer. He was transferred to the inside plant department as substation field engineer the following year, and in 1927 he became engineer of system protection. In 1930 he became a staff engineer in the office of the chief electrical engineer, in 1932 was made development engineer, and since 1936 has held his present position. Mr. LeClair has been a member of the AIEE board of directors since 1941, and has served on the membership committee, and the committees on land transportation, legislation affecting the engineering profession, and the Engineering Societies' joint committee on Chicago Century of Progress Exposition (1932–33). He is now serving on the 1942–43 Edison Medal, standards, and technical program committees. He holds patents on several inventions and is the author of various technical papers and articles. He is director and chairman of the legislating committee of the Illinois Engineering Council, and a member of the Western Society of Engineers and the Illinois Society of Engineers.

S. B. Williams (M'37) editor, *Electrical World*, New York, N. Y., has been appointed chairman of the AIEE Lamme Medal committee for the year 1942–43. He has served on the publication and Lamme Medal committees since 1939, and was appointed acting chairman to fill a vacancy on the latter in May 1942. He was born August 2, 1889, at Orinoke, Kans., and received the degrees of bachelor of literature (1912) and bachelor of electrical engineering (1914) from Princeton University. In 1914 he joined the staff of the *Electrical World*, McGraw-Hill Publishing Company, New York, N. Y., later becoming assistant managing editor. He became associated with the Gage Publishing Company, New York, N. Y., in 1922, as managing editor and later editor of the *Electrical Record*. He was manager and editor of *The Electragist* from 1924–28, when he returned to McGraw-Hill Publishing Company as editor of *Electrical Contracting*. He became managing editor of *Electrical World* in 1936 and has held his present office since 1938. He is a member of the Illuminating Engineering Society.

C. E. Hickey (A'20) former manager, distribution operation department, Consolidated Edison Company of New York (N. Y.) Inc., has been appointed manager of the newly created outside plant construction department. He has been employed continuously by Consolidated Edison and allied companies since 1904. **J. E. Gallagher** (A'24, M'36) formerly general superintendent, station construction and shops, has been transferred as general superintendent to the department of electrical construction. He came to Consolidated Edison from the Brooklyn (N. Y.) Edison Company. **G. C. Baker** (A'20, M'25) engineer of estimates, contract control and inspection department, has been made superintendent of estimates and orders. **E. E. Hill** (A'16) formerly general superintendent, distribution construction bureau, has been transferred as manager of the distribution operation department. He first joined the company in 1904 as assistant meter tester, the New York (N. Y.) Edison Company. **W. T. Grumbly** (A'28, M'36) head of the outside plant inventory bureau, was appointed superintendent of the Manhattan and Bronx electrical division of meter department, and was later transferred as head of the test bureau of the electrical engineering department.

W. P. Graham (A'02, F'23) former chancellor of Syracuse University, Syracuse, N. Y., retired in June. Born in Oswego, N. Y., November 24, 1871, he received the degrees of bachelor of science from Syracuse University (1893), and doctor of philosophy (1897) from the University of Berlin. Following a year's study in the electrical engineering laboratory at the Technische Hochschule, Darmstad (1897–98), he returned to the United States as associate professor of electrical engineering in the college of liberal arts at Syracuse University. In 1902, when the college of applied science was established, he was appointed head of the department of electrical engineering, and in 1912 became dean of the college of applied science. He continued in that capacity until 1922, when he was appointed vice-chancellor, and since 1937 he has served as chancellor. At the 1942 commencement exercises of Syracuse University he was awarded the George Arents Medal. In 1938 he was awarded the honorary degree of doctor of laws by Colgate University. He is a member of the American Association for the Advancement of Science, American Astronomical Society, Phi Beta Kappa, Sigma Xi, and Tau Beta Pi, and has been active in the work of the Institute's Syracuse Section.

R. D. Sloan (A'17, M'28) acting dean, college of mechanic arts and engineering, and head of the electrical engineering department, State College of Washington, Pullman, has been appointed dean. Graduated with the degrees of bachelor of science in electrical engineering (1913), University of Montana, and electrical engineer (1921), Montana State College, he entered the testing department of General Electric Company, Schenectady, N. Y., and Pittsfield, Mass. From 1915–16 he worked on the construction and operation for the Great Falls (Mont.) Power Company. From 1916–22 he served first as instructor and then assistant professor of electrical engineering at Montana State College, Bozeman, excepting a period during World War I (1917–19) in which he served in the United States Navy. From 1922–23 he was assistant professor of electrical engineering, Yale University, New Haven, Conn., and in 1923 he joined the electrical engineering faculty of the State College of Washington, Pullman, as associate professor. In 1926 he received his full professorship, and became vice-dean of the college of engineering.

J. S. Hagan (A'20, M'31) formerly western railway sales manager, Thomas A. Edison, Inc., Edison Storage Battery Division, Chicago, Ill., has been appointed manager of the northwestern district, manufacturing and repair department, Westinghouse Electric and Manufacturing Company, La Grange, Ill. He holds the degree of bachelor of science in electrical engineering (1916) from Kansas State Agricultural College. He first joined the Westinghouse company in 1916, entering the graduate student course, and in 1917 was assigned to the railway section of the general engineering department. From 1917–19 he served with the United States Army, returning to the company at the close of World War I. In 1922 he was sent by them to Java in connection with the electrification of a railroad. From 1924–27 he was associated with the Baltimore and Ohio Railroad, and from 1927–35 he was head of the electrical department of the Central Railroad of New Jersey. In 1935 he entered the employ of the Thomas A. Edison company, as railway sales manager until his return to the Westinghouse company.

R. R. Robley (A'18, M'20) formerly assistant to the vice-president of the Portland (Oreg.) General Electric Company, has recently been appointed assistant to the president. Born May 31, 1875, in Walla Walla County, Wash., he received the degree of bachelor of science in electrical engineering from the University of Oregon in 1901. He has been associated with the Portland General Electric Company since 1904. He has occupied various positions in the operating department of the company, becoming superintendent of operation in the power and light department in 1927 and assistant to the vice-president in 1940. **F. R. Groch** (A'40) formerly junior engineer in the rates and statistics department, has been appointed assistant to the vice-president to succeed Mr. Robley. He received the degree of bachelor of science in electrical engineering from California Institute of Technology in 1930. Prior to his affiliation with Portland General Electric Company in 1940, he was associated with several electrical utility companies in California.

Donald Gunn (M'36) formerly assistant to the chief engineer, Pennsylvania Water and Power Company, Baltimore, Md., has been made chief engineer. Mr. Gunn joined the engineering staff of the company in 1930. Graduated from Georgia School of Technology in 1925 with the degree of bachelor of science in mechanical and electrical engineering, he gained his engineering experience with the Duquesne (Pa.) Light Company, the American Rolling Mills Company, and the Byllesby engineering and Management Corporation, Pittsburgh, Pa. **G. W. Spaulding** (A'24, M'32) assistant chief engineer, has been appointed superintendent of power. He received the degree of bachelor of science from Massachusetts Institute of Technology in 1921. In 1924 he became associated with the company as test engineer, and successively became chief of tests (1925), assistant to the general superintendent in charge of power studies and system planning (1928), and assistant chief engineer (1939).

D. W. Atwater (A'34) formerly manager of the commercial engineering department, Westinghouse Lamp Division, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J., has been appointed head of the company's newly created illuminating engineering department. He is in charge of planning for the application of recently developed light sources to the expanding lighting needs of the nation. He received the degree of bachelor of mechanical engineering in 1916 from Stevens Institute of Technology, and joined the General Electric Company, Harrison, N. J., as factory engineer in the Edison Lamp Works. From 1919–20 he served as specification engineer, Western Electric Company, New York, N. Y., and in 1920 joined the Westinghouse company. He has been associated with the Westinghouse company continuously since 1920, and was made manager of commercial engineering in 1934.

Bartow Van Ness, Jr. (A'23, M'35) formerly assistant to the chief engineer of the Pennsylvania Water and Power Company and the Safe Harbor Water Power Corporation, Baltimore, Md., has been appointed chief engineer of the latter corporation. Mr. Van Ness was graduated from Johns Hopkins University in 1921 with the degree of bachelor of electrical engineering, and from Massachusetts Institute of Technology in 1922 with the degree of master of science in electrical engineering. He has been with the companies continuously since 1922, and has worked on the Safe Harbor project from the preliminary estimate studies to its present state. He is responsible for the electrical engineering and electrical design of the power plant, as well as the single phase Conestoga substation for supply of power to the Pennsylvania Railroad. He has also been associated in the solution of numerous high tension interconnecting problems.

H. E. Becker (A'37) central-station department, Westinghouse Electric and

Manufacturing Company, San Francisco, Calif., has been appointed supervisor of the maintenance sales department for the Pacific Coast district. He was graduated from Leland Stanford University in 1922 with the degree of bachelor of arts in electrical and mechanical engineering. He first entered the employ of the Westinghouse company, East Pittsburgh, Pa., in 1922, in the student course in electrical engineering, and in 1923 was assigned to the central-station division. In 1925 he was transferred to the San Francisco office as sales engineer in the industrial division, and later was assigned to the Stockton, Calif., office to handle work of both central-station and industrial divisions. In 1927 he returned to San Francisco as sales engineer for the central-station division.

N. S. Hibshman (A'27, F'41) formerly associate professor of electrical engineering, Lehigh University, Bethlehem, Pa., has been appointed head of the department of electrical engineering at New York University, N. Y. He was born January 20, 1902, at Harrisburg, Pa., and received the degrees of bachelor of science in electrical engineering (1924) from Pennsylvania State College, and master of science in electrical engineering (1927) from Lehigh University. He was a member of the electrical engineering faculty of Lehigh University from 1920–42, becoming successively assistant professor and associate professor. He has served as AIEE vice-president representing the middle Eastern District, and is a member of Phi Kappa Phi, Eta Kappa Nu, Tau Beta Pi, and Sigma Xi.

L. T. Williams (A'27) division engineer, Southwestern Gas and Electric Company, Shreveport, La., has been named acting chief engineer of the general department. He received the degree of bachelor of science from Texas Agricultural and Mechanical College, and joined the company in 1924. He has been employed by that company since, except for a brief period with the Dallas (Tex.) Power and Light Company in the designing division. In 1938 he was made division engineer for the East Texas oil fields district and in 1939 was transferred to Texarkana, Tex., as assistant to the chief engineer of the company.

E. J. Rutan (A'20, M'29) formerly test engineer, technical service, Consolidated Edison Company of New York (N. Y.), Inc., has transferred to Chemical Construction Corporation, New York, N. Y. He had been associated continuously with the Consolidated Edison Company since 1919, working as test engineer in the test department, becoming superintendent in 1924, and later becoming supervisor of the test bureau. He was chairman of the AIEE technical committee on instruments and measurements during 1930–33, and has served on that committee since 1926, and the standards committee from 1933–42.

R. M. Smith (A'35) engineering manager, wiring device division, The Bryant Electric Company, Bridgeport, Conn., has joined Roller-Smith Company, Bethlehem, Pa., as assistant chief engineer. He received the degree of bachelor of science in electrical engineering from the University of Washington (1925) and was employed by Westinghouse Electric and Manufacturing Company, Newark, N. J., for 16 years as section engineer on relay design and application prior to his affiliation with The Bryant Electric Company. He has served on the AIEE committee on protective devices, and is the author of several technical articles.

W. P. Doolittle (A'24, M'30) industrial engineer, Kansas City (Mo.) Power and Light Company, retired recently. He was first employed in the power and lighting sales department of that company in 1904, and in 1905 was placed in charge of the department. From 1911–18 he was operator of a small private power and lighting plant which he purchased and installed on Isles of Pines, Cuba. In 1919 he returned to Kansas City Power and Light Company, and has been engaged with them continuously since then in the sale of service, power, and equipment.

Gerard Swope (A'99, F'22) honorary president of the General Electric Company, New York, N. Y., has been reappointed president of that company. He joined the General Electric company at Chicago, Ill., in 1893, and after service with the Western Electric Company, Chicago, Ill., and the International General Electric Company, he became president of the General Electric Company in 1922, remaining until 1940 when he retired.

W. B. Elmer (A'35) head of the distribution technical division, Boston (Mass.) Edison Company has joined the engineering staff of the Westinghouse Electric and Manufacturing Company, Sharon, Pa., to do research work. He was graduated from Massachusetts Institute of Technology with the degree of bachelor of science in 1922 and in that year was employed by the Edison Electric Illuminating Company of Boston (later the Boston Edison Company).

R. M. Cunningham (A'40) senior staff engineer, Bell Telephone Company of Pennsylvania, Philadelphia, has been transferred to the operating results division, American Telephone and Telegraph Company, New York, N. Y., where he is working on inventory and appraisals. He has been doing similar work with the Bell company since 1938.

S. A. Schelkunoff (M'34) consultant in electromagnetic theory, research department, Bell Telephone Laboratories, Inc., New York, N. Y., has been awarded the Morris Liebmann Memorial Prize by the Institute of Radio Engineers "for his contributions to the theory of electromagnetic fields in wave transmission and radiations."

J. M. Fluke (A'37) lieutenant (junior grade) United States Naval Reserve, Bureau of Ships, Navy Department, Washington, D. C., and formerly of the General Electric Company, Bridgeport, Conn., has received a special Merit Award from that company for his contributions to the design and manufacture of strip silver contacts.

H. W. Martin (A'40) sales engineer, estimating and engineering publicity department, Allis-Chalmers Manufacturing Company, Boston, Mass., was awarded a $100 prize by the Compressed Air Institute, Cleveland, Ohio, for a paper demonstrating the use of compressed air blasts for breaking circuits in high voltage lines.

L. G. Woodford (M'31, F'42) chief engineer, operation and engineering department, American Telephone and Telegraph Company, New York, N. Y., has been granted leave of absence to assume his duties as deputy director of procurement in the headquarters of the United States Army Services of Supply.

O. P. Cleaver (A'36) head of the illumination section, commercial engineering department, Westinghouse Lamp Division, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J., has been commissioned a captain in the United States Army Engineer Corps.

A. C. Marshall (A'14, F'29) president and general manager, Detroit (Mich.) Edison Company, has been elected vice-president and a member of the board of lifetime trustees of the Horace H. Rackham Engineering Foundation, Detroit, Michigan.

George Sutherland (A'20, F'27) general stores manager, purchasing and stores department, Consolidated Edison Company of New York, N. Y., has been appointed War Production Board regional salvage manager for New York and New Jersey.

J. E. Jackson (A'26) district manager of the Appalachian Electric Power Company, Lynchburg, Va., has been granted wartime leave of absence to join the staff of the United States Office of Scientific Research and Development, Washington, D. C.

W. H. Matthies (A'26, M'29) director of switching development, Bell Telephone Laboratories, New York, N. Y., was recently elected a member of the executive committee of the Edward J. Hall chapter, Telephone Pioneers of America.

H. A. Walsh (A'30, M'31) electrical engineer, Doble Engineering Company, Medford Hillside, Mass., has been appointed business manager for El Paso (Tex.) Electric Company. He had been employed by the Doble company since 1923.

H. J. Chanon (A'33, M'41) electrical engineer, General Electric Company, Nela Park, Cleveland, Ohio, has been transferred to the company's South Pacific division, Los Angeles, Calif.

W. F. Kennedy (A'22) superintendent, meter department, New York and Queens

Electric Light and Power Company, Flushing, N. Y., has been assigned also the Brooklyn meter division.

R. E. Mathes (A'37) assistant division head, terminal facilities research laboratory, RCA Communications, New York, N. Y., is serving as a lieutenant in the United States Naval Reserve.

S. M. Sharp (A'26, M'42) former chief engineer of the Southwestern Gas and Electric Company, Shreveport, La., is now serving as captain in the signal corps of the United States Army.

OBITUARY • • • •

Leon Byron Woodworth (A'00, M'29) retired consulting engineer, Durban, South Africa, died May 29, 1942. He was born March 4, 1874, in Arcade, N. Y., and studied at Franklin Institute and Canasius College. After a six-month apprenticeship with General Electric Company, Schenectady, N. Y., in 1893, he joined the Buffalo (N. Y.) Electric Transit Company, in 1894, as construction superintendent, later becoming manager. In 1895 he resigned and left for South Africa, where he was engaged in constructing electrical plants. From 1898–1908 he was assistant mechanical and chief electrical engineer for the New Heriot Gold Mining Company, Johannesburg, excepting the period of the Boer War (1899–1902), during which he served with the British forces in the Royal Engineers. In 1909 he became assistant to the consulting electrical and mechanical engineer for H. Eckstein and Company, Johannesburg, retaining that position when the company became the Central Mining and Investment Corporation. He was employed by that company until his retirement in 1941, becoming sectional engineer in the electrical and mechanical department in 1923, and consulting engineer in 1939. In addition to his duties with the Central Mining and Investment Corporation, he was engaged in research work at the Rand Mines Mechanical Laboratory, Johannesburg, and served as engineering consultant for a number of mining and industrial plants. He was the holder of several patents on methods of ore separation. Mr. Woodworth was a member of the Institution of Electrical Engineers, England, the South African Institute of Electrical Engineers, and the Certificated Engineers, Union of South Africa.

E. Dean Tanzer (A'15) engineer, United Engineers and Constructors, Inc., Philadelphia, Pa., died June 11, 1942. Born October 11, 1889, in Lowville, N. Y., Mr. Tanzer received from Syracuse University the degree of bachelor of science in electrical engineering in 1911. Upon graduation he became an engineering apprentice with Westinghouse Electric Company, East Pittsburgh, Pa., and in 1912 was instructor in electrical engineering, Louisiana Industrial Institute, Ruston. After a brief period with Commonwealth Edison Company, Chicago, Ill., as engineer on central and substation design, he became instructor in electrical engineering, University Extension, City of Milwaukee, Wis., in 1913. From 1914–16 he was assistant professor of electrical engineering at Lafayette College, Easton, Pa., and from 1916–18 he held a similar position at Georgia School of Technology, Atlanta. In 1919 he became engineer in the transmission and distribution department, Philadelphia (Pa.) Electric Company. From 1927–30 he was consulting engineer with Day and Zimmermann Company, Philadelphia, Pa., and held a similar position with United Engineers and Constructors, Incorporated, from 1930 until his death. In addition he had been head of the electrical engineering department of Drexel Evening School, Philadelphia, Pa., since 1919. He was a member of the Transformer Oil Advisors, United States National Committee of the International Electrotechnic Commission, and was official delegate to the meetings of the commission in Bellagio, Italy, 1927, and Stockholm, Sweden, 1930. He was also a member of the Illuminating Engineering Society, the National Electric Light Association, the American Society for Testing Materials, and Tau Beta Pi.

Frank G. Frost (M'22) general superintendent, electric department, New Orleans, (La.) Public Service, Inc., died July 1, 1942. Born February 1, 1877, in Maltoon, Ill., Mr. Frost was graduated from the University of Illinois in 1901 with the degree of bachelor of arts in mechanical engineering. During 1901 he worked as draftsman for A. L. Ide and Sons, Springfield, Ill., and in 1902 became chief engineer of the Rorig Engineering Company, Columbus, Ohio. From 1904–07 he was chief draftsman for the Sheffield Car Company, Three Rivers, Mich., and from 1907–15 he was associated with Ford, Bacon and Davis Engineers, New York, N. Y., in various duties in Birmingham, Ala., Little Rock, Ark., and Houston, Tex. In 1915 he was appointed general superintendent for Houston (Tex.) Lighting and Power Company, and in 1918 became superintendent of power for the New Orleans (La.) Railway and Light Company. He worked continuously for that company and its successor, the New Orleans (La.) Public Service, Incorporated, from 1918 until his death, advancing to general superintendent of the electrical department in 1921. Mr. Frost helped organize the New Orleans section of AIEE in 1933, and was section chairman for the year 1937–38. He was chairman of the committees on meeting arrangements and general entertainment for the December 3–5, 1941 Southern District meeting held in New Orleans, and was chairman of the AIEE committee on civil protection in New Orleans at the time of his death. He was also a member of The American Society of Mechanical Engineers.

Harold Constad (A'35) managing director, Batwin Electric Motors, Ltd., London, England, died September 1940. He was born May 26, 1898, and studied at the Perse School, Cambridge, British Institute of Engineering Technology. During World War I (1914–18) he served with the Royal Army Service Corps in the mechanical section, and in 1919 he became electrical engineer for Moss Empires, Ltd., England. In 1925 he joined the electrical section of L. Constad and Company, Ltd., Engineers, Sheffield, and in 1930 he became managing director of Power Contracts, Ltd., London. He became director of electrical sales for the Batwin Electric Motors, Ltd., London, in 1939, and in 1940 was appointed managing director, a position he held until his death.

James Singleton Porter (A'35) sales department, Westinghouse Electric and Manufacturing Company, Oklahoma City, Okla., died May 2, 1942. Born October 17, 1899, in Lena, Miss., Mr. Porter received the degree of bachelor of science in electrical engineering in 1923 from Mississippi Agricultural and Mechanical College. Following graduation he joined the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa., remaining with the company until his death. His first year was spent in the graduate student course in Pittsburgh, and in 1924 he was transferred to the district sales office as sales assistant. Since 1925 he has served the Westinghouse Electric company in Oklahoma City, Okla., in the sales and application engineering department.

F. A. Calmus (A'29) Pacific Coast manager, Elliott Company, San Francisco, Calif., died August 2, 1942. Born March 1, 1894, in Marshalltown, Iowa, he received the degree of bachelor of science in electrical engineering from Iowa State College in 1917. In 1919 he entered the employ of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and in 1921 he joined the Elliott Company, Kansas City, Mo., ultimately becoming manager. In 1928 he was transferred to the San Francisco office, as vice-president. He later became district sales manager. He was also a member of The American Society of Mechanical Engineers.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting on September 24, 1942, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Cleary, L. H., partner, Weschler and Cleary, Washington, D. C.
MacNeill, J. B., manager, Switchgear Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Miller, J. H., assistant chief engineer, Weston Electrical Instrument Corporation, Newark, N. J.

3 to grade of Fellow

To Grade of Member

Austin, F. M., vice-president, Houston Lighting and Power Company, Houston, Texas.
Bass, N. I., supervisor of Western division, Houston Lighting and Power Co., Rosenberg, Texas.
Bender, D. S., field engineer, Bell Telephone Laboratories, Inc., New York, N. Y.
Blackledge, R. S., chief assistant designer, Veritys Ltd., Aston, Birmingham, England.
Bowman, N., district planning engineer, Detroit Edison Company, Detroit, Mich.
Bustard, W. B., electrical engineer, Headman, Ferguson and Carollo, Phoenix, Ariz.
Capon, A. E., electrical engineer, City of Burbank, Calif.
Casey, E. J., application engineer, General Electric Company, Philadelphia, Pa.
Clarke, T. C., district manager, Northern Electric Company Ltd., Vancouver, B. C.
Cole, F. H., owner, Cole Electric Company, Los Angeles, Calif.
Condon, E. S., president, Condon and Young, Inc., Los Angeles, Calif.
Davidge, R. C., office engineer, International General Electric Company, Schenectady, N. Y.
Dietz, W. F., assistant manager, Westinghouse Electric and Manufacturing Company, Washington, D. C.
Dixon, A. R., staff engineer, American Telephone and Telegraph Company, New York, N. Y.
Drake, E. F., electrical superintendent, National Paper Products Co., Port Townsend, Wash.
Dyer, C. E., general foreman, Pacific Gas and Electric Company, Santa Maria, Calif.
Fathauer, W., assistant chief engineer, General Electric X-Ray Corporation, Chicago, Ill.
Ferguson, F. H., superintendent, light and power, Puget Sound Power and Light Co., Bremerton, Wash.
Frantz, J. D., assistant superintendent, Northwestern Electric Company, Portland, Oreg.
Gates, S. E., manager, General Electric Company, Los Angeles, Calif.
Giesecke, H. W., assistant to electrical engineer, Consolidated Gas Elec. Light and Power Company, Baltimore, Md.
Goodridge, W. N., electrical designer, J. G. White Engineering Corporation, New York, N. Y.
Gunzburger, E., chief electrical design engineer, Midwestern Engineering and Construction Company, Tulsa, Okla.
Gustafson, O. A., central station engineer, General Electric Company, Los Angeles, Calif.
Hamilton, J. P., assistant electrical engineer, Tennessee Valley Authority, Wilson Dam, Ala.
Hartzell, H. W., engineer, Commonwealth and Southern Corporation, Jackson, Mich.
Hedges, L. B., chief load dispatcher, Bureau of Power and Light, Los Angeles, Calif.
Hewitt, C. D., engineer, Southern New England Telephone Company, New Haven, Conn.
Howard, F. M., superintendent, meter and service department, Mountain States Power Company, Casper, Wyo.
Johnson, V. E., sales engineer, Westinghouse Electric and Manufacturing Company, Milwaukee, Wis.
Kipp, E. B., meter instrument relay specialist, Westinghouse Electric and Manufacturing Company, Los Angeles, Calif.
Kirkish, J. J., engineer, Louis Allis Company, Milwaukee, Wis.
Logan, A., engineer and manager, The Dunoon and District Electricity Supply Company Ltd., Dunoon, Argyll, Scotland.
Mansfield, C. G., assistant underground engineer, Bureau of Power and Light, Los Angeles, Calif.
Myers, A. F., assistant engineer, Bureau of Reclamation, Bonneville-Grand Coolee Dam, Wash.
Oliver, R. C., electrical engineer, Black and Veatch, Kansas City, Mo.
Phillips, R. L., superintendent, Sterlington Steam Electric Station, Sterlington, La.
Rogers, W. T., safety and research consultant, Ebasco Services, Inc., New York, N. Y.
Rosenkrans, A. A., assistant electrical engineer, Underwriters Laboratories, Inc., New York, N. Y.
Russell, F. A., instructor, Newark College of Engg., Newark, N. J.
Sasscer, C. D., electrical engineer, Office of Chief of Engineers, Washington, D. C.
Schonborn, R. J., electrical engineer, Bureau of Power and Light, Los Angeles, Calif.
Smith, S. B., electrical engineer, Ebasco Services, Inc., New York, N. Y.
Sylvane, A. A., engineer in charge, Commercial Radio-Sound Corp., New York, N. Y.
Techlenburg, H. C., electrical engineer, Mason and Hanger Company, Merrimac, Wis.
Tenney, G. C., editor and publisher, Electrical West, San Francisco, Calif.
Watson, G. G., electrical engineer, Bureau of Power and Light, Los Angeles, Calif.

47 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before October 31, 1942, or December 31, 1942, if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Blomquist, H. R. (Associate re-election), United Electric Railways Company, Providence, R. I.
Duryee, L. M. (Member), Connecticut Light and Power Company, Waterbury, Conn.
Nelson, R. A., Simplex Wire and Cable Company, Cambridge, Mass.
Thynell, G. M., Bristol Company, Waterbury, Conn.

2. Middle Eastern

Block, M. J., United States Navy Department, Bureau of Ships, Washington, D. C.
Brandenburg, H. V., Bureau of Yards and Docks, Washington, D. C.
Douville, E. L., G. L. Martin Company, Baltimore, Md.
Herbert, M. G., Cincinnati and Suburban Bell Telephone Company, Cincinnati, Ohio.
Jones, E. E. (Member), Stone and Webster Engineering Corporation, Williamsport, Pa.
Kern, K. C., The Baltimore Transit Company, Baltimore, Md.
Longwell, R. R., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Miner, J. D., Jr. (Member), Westinghouse Electric and Manufacturing Company, Lima, Ohio.
Omin, W. W., Navy Yard, Philadelphia, Pa.
Osborne, W. S., New York Shipbuilding Corporation, Camden, N. J.
Platt, L. R., Air-Track Manufacturing Corporation, College Park, Md.
Wandersleben, A. E., Electric Controller and Manufacturing Company, Cleveland, Ohio.

3. New York City

Barte, M. L. (Member), Nichols Engineering and Research Corporation, New York, N. Y.
Blackwedel, G. H. (Member re-election), Burns and Roe, New York, N. Y.
Brody, M. K. (Member), McCall Corporation, New York, N. Y.
Davies, R. J. (Member), E. J. White Company, Newark, N. J.
DeCarlo, C. J., C. H. Stevens Company, New York, N. Y.
Falvey, W. M., Wilputte Coke Oven Corporation, New York, N. Y.
Glaser, E. M., Square D Company, Elmhurst, N. Y.
Jorch, W. F., Roosevelt Aviation School, Mineola, N. Y.
Kay, E. T., Wilputte Coke Oven Corporation, New York, N. Y.
Malone, J. F. (Member), New York and Queens Electric Light and Power Company, Long Island City, N. Y.
Peters, R. C. (Associate re-election), Gibbs and Hill Incorporated, New York, N. Y.
Rayment, W. (Member), Stuyvesant High School, New York, N. Y.
Rose, D. J., Westinghouse Electric and Manufacturing Company, Bloomfield, N. J.
Ruscher, J. E., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Whitaker, U. A. (Member), Aircraft-Marine Products Inc., Elizabeth, N. J.

4. Southern

Christenbury, F. L. (Member re-election), Criminal Court Building, Memphis, Tenn.
Davis, R. S., Florida Power and Light Company, Sarasota, Fla.
Hoilman, C. W. (Member), Virginia Electric and Power Company, Richmond, Va.
Hollis, M. O. (Associate re-election), 3621 San Pedro, Tampa, Fla.
Lang, H. C. (Member), Giffels and Vallet, Inc., Norfolk, Va.
Riddick, A. G. (Member re-election), C. T. Patterson Company, Inc., New Orleans, La.
Romanowitz, H. A. (Member), University of Kentucky, Lexington, Ky.
Wasson, J. M., Southern Bell Telephone and Telegraph Company, Jacksonville, Fla.
Williams, C. H., Chesapeake and Ohio Railway Company, Richmond, Va.

5. Great Lakes

Brueck, H. L. (Associate re-election), 53 West Jackson Boulevard, Chicago, Ill.
Edwards, J. R., Delco Remy Corporation, Anderson, Ind.
Freezee, W. D. (Member), American Telephone and Telegraph Company, Chicago, Ill.
Lynette, H. A., II (Member), Mason and Hanger Company, Baraboo, Wisc.
Reed, E. V., F. Mattern Manufacturing Company, Chicago, Ill.

6. North Central

Bird, E. F. (Member), The Mountain States Telephone and Telegraph Company, Denver, Colo.
Birkett, C. M. (Member), Steamboat Springs Electric Engineering Company, Steamboat Springs, Colo.
Colby, H. B., Public Service Company of Colorado, Denver, Colo.
Mayer, F. N., United States Army Air Base, Rapid City, S. Dak.
Rumohr, C. G., Public Service Company of Colorado, Denver, Colo.
Searle, G. W., Mountain States Telephone and Telegraph Company, Denver, Colo.

7. South West

Cooper, P. L., Jr., Southwestern Bell Telephone Company, Houston, Texas.
Courtney, G., Electric Supply Company, Galveston, Texas.
Hinton, J. F., American Telephone and Telegraph Company, St. Louis, Mo.
Landwehr, I. H., Union Electric Company of Missouri, St. Louis, Mo.
McDonald, W. C., Southwestern Bell Telephone Company, Houston, Texas.
Rothpletz, M. W., Rural Electrification Administration, St. Louis, Mo.

8. Pacific

Bishop, A. M., Navy Department, Mare Island, Vallejo, Calif.
Crow, J. R. (Member), Southern California Telephone Company, Los Angeles, Calif.
Elliott, J. L. (Associate re-election), 520 Pine Street, Redwood City, Calif.
Fleming, J. A., Sterling Electric Motors, Inc., Los Angeles, Calif.
Knopp, H. P., Electric Facilities Inc., Oakland, Calif.
LaPlant, O., United States Engineers, San Francisco, Calif.
Radcliffe, H. D., California Shipbuilding Corporation, Wilmington, Calif.
Rector, E. M., Basic Magnesium Incorporated, Las Vegas, Nev.
Tarran, L. (Member), C. C. Moore and Company, San Francisco, Calif.

9. North West

Rohrer, D. D., Washington Water Power Company, Spokane, Wash.

10. Canada

Ferguson, A. F., Hydro Electric Power Commission of Ontario, Burlington, Ont.
Hedley, F. H., Westinghouse Company Ltd., Vancouver, B. C.
Holmes, R., International Silver Company, Niagara Falls, Ont.
Metcalfe, C., Defense Industries, Limited, Nitro, Quebec, Canada.

Total United States and Canada, 71

Elsewhere

Badham, L. H. L. (Member), The Switchgear and Erection Co. (Pty) Ltd., Johannesburg, South Africa.
Boeuf, A., British Power Transformer Company Ltd., Queensway, Ponders End, Middlesex, England.
Fleming, G., Usina Electrica General Alvear, Mendoza, Argentina, S. A.
Kinnaird, W. R., Marlborough Electric Power Board, Blenheim, New Zealand.
Steward, C. E. (Member), Johnson and Phillips Ltd., Charlton, London, S E 7 England.
White, C. H., Public Works Department, Electrical Branch, Sydney, New South Wales, Australia.

Total, elsewhere, 6

OF CURRENT INTEREST

Salvage Program in Every Plant

A salvage program in every plant, factory, shop, or yard is the backbone of the War Production Board's campaign to put our national waste back into production. It is the job of American industry, says the American Industries Salvage Committee, to see that all broken down, dismantled, and unusable materials are made available for scrap, if our steel mills are to be sure of enough scrap to keep up the steel production for the planes, tanks, guns, and ships we need to win the war. Methods of organizing a scrap campaign that can be used effectively by any plant, regardless of size or type, are announced by the salvage committee.

The organization to operate an effective salvage collection need not be elaborate or costly. It works best when it is simple and unemcumbered with extra officials and unnecessary steps. An able executive of the company heads the program as salvage manager. He works with superintendents and foremen in various departments, and he must be armed with ample authority to make decisions to scrap unused material.

To start the ball rolling, the foremen should make a survey of their departments and report to the salvage manager machines and equipment which are obsolete or out of active production. The salvage manager should make a written report of these findings, as a basis for action.

It is management's function to mark and send to the scrap heap equipment that is obsolete. After inspection, use this yardstick in coming to a decision: If a machine or other piece of equipment hasn't been used for three months, and if it can't be proved that it will be used in the next three, turn it over where it can be used—or scrap it. Either dispose of equipment in industry if there is a call for it, or put it to work as scrap for the weapons of war.

Once such equipment has been marked for scrap, a responsible shop man should supervise its dismantling and classification. The assortment may be made to yield valuable replacement parts for machines in operation. Cutting down the need for purchasing new parts will remove the plant from the competition for equipment.

No salvage campaign can be successful without the wholehearted co-operation of every person in the plant. Remember that even the most worth-while cause needs the proper promotion to put it across. The battle for scrap to keep our production going is dramatic enough to put over with a bang. Stunts, posters, billboards, and frequent mention in company publications or house organs are excellent vehicles for capturing and sustaining employees' interest in the program. In most plants, excellent talent can be recruited for this promotion from among the employees.

Workers should be urged to contribute suggestions and ideas for increasing salvage output. These may either be cleared through the foreman or written on slips and deposited in a suggestion box. Occasional rewards and incentives for outstanding co-operation in the salvage campaign will bring out employees' initiative. Workers can make or break a program. If their enthusiasm is enlisted and maintained, they will prove collaborators who will match the efforts of management.

Bins and containers—preferably displaying a poster or a slogan—should be placed in strategic spots throughout yards and plants. These serve as depositing places for production scrap, salvaged waste materials, and contributions which workers bring from their home. Separate containers for different metals, rubber, twine, and so forth, will save time sorting the material.

Scrap is of use to the war effort in direct proportion to the speed with which it is gotten back into production. Arrange regular daily or biweekly schedules for the various departments and sources of supply. The salvage manager should see to it that collections are turned in on time to a central collection depot in the plant. Select a definite date each week for shipment to a junk dealer, or have the salvage shipped by the company to the nearest collection point.

Remember that scrap bears no label. It is old jigs, dies, castings; or it is a ten-ton machine no longer being used. Waste metal, rubber, burlap, and other critical materials are valuable even in small amounts. Every pound of these materials can be salvaged by industry for war work.

Treat the factory to a house cleaning. What was junk six months ago has its place in the war effort now. Sort rubbish carefully. Salvage what can be used, and burn or otherwise dispose of the real rubbish that cannot. Keep the premises clear of debris. This is the only method by which it can be made certain that there is nothing further to be salvaged.

Every bit as important as salvaging vital materials is the need to conserve what we have. Use less by making better use of what we have. Get this message across to the workers. It will benefit our sons and relatives in the armed forces. By preventing spoilage and breakage, the material we work with can be turned against the enemy.

In order to co-ordinate the salvage campaign in the individual plant with the national effort, it is essential that regular reports on the amounts collected, according to classification, be delivered to the industrial salvage committee set up by the War Production Board in your community.

Above all, make clear to all personnel that until the day when we have actually turned out all the war equipment we need to smash the Axis, salvage and conservation are going to remain vital phases of our production. Unless our scrap is turned into weapons *now*, America will be fighting the war with one hand tied behind its back.

Get Out the Industrial Scrap

1. Head up the campaign by appointing an able executive of the company, armed with authority to act.
2. Use posters, illustrations, pay-envelope stuffers, and all other publicity means to enlist all employees in scrap campaign.
3. Comb plant and yards for dormant scrap and unusable and abandoned equipment.
4. Survey all plant equipment, particularly idle, standing, or discarded machines.
5. Classify and segregate scrap, and supervise its handling.
6. Make each foreman responsible for preventing spoilage and waste in his department.
7. Report promptly equipment which is obsolete. If equipment has not been used in three months, and it can't be proved that it will be used in the next three, turn it over where it can be used . . . or scrap it.
8. Salvage usable parts from equipment marked for scrapping.
9. Speed return of scrap to mills and refineries through existing channels. Report regularly on collections of scrap to the industrial salvage committee set up by the War Production Board in your community.
10. Enforce monthly rechecks in every department to find scrap material previously overlooked.

Need for Copper Is Urgent

Emergency requests for 500,000 pounds of copper a day are being received at the present time from war plants and the armed services, the inventory and requisitioning branch of the War Production Board announced recently. Transfer of copper from idle and excessive inventories to producers needing this critical metal is necessary if these requests are to be met so that manufacture of munitions, airplanes, and tanks can continue at peak production.

"Copper and copper base alloys are now being allocated from idle inventories into strategic war production at the rate of over 4,000,000 pounds a week," declared E. A. Tupper, chief of the inventory and requisitioning branch. "But while this is double the original estimate for this date," he continued, "the current needs of our vast war production machine are now so great that even this figure must again be doubled within the course of the next few weeks." By early September, approximately 29,700,000 pounds of copper and copper base alloys had been allocated from immobilized stocks to war production channels through the WPB copper-recovery program. Of this total 2,400,000 pounds were allocated for stockpiling to meet future anticipated demands for standard shapes and sizes of mill products; 6,300,000 pounds were reported and allocated as scrap; 9,300,000 pounds were allocated, or known to have been moved for use in existing form, and 11,700,000 pounds were allocated to brass mills and ingot makers for remelting.

"Over 14,000 firms have reported a total of 111,000,000 pounds of idle and excessive inventories of copper and copper base alloys. Much of the copper reported has been offered for voluntary sale at the government's prices. That which the owner refuses to sell but which is nevertheless needed for war production will be requisitioned," Mr. Tupper declared.

A special unit from the copper branch of WPB has been set up in the offices of Copper Recovery Corporation, 200 Madison Avenue, New York, N. Y., to locate copper in the forms needed, and to redistribute it to war plants urgently requiring it because of unforeseen material shortages, plant breakdowns, receipt of new war orders, or other emergencies. In most of these emergencies, the war plant cannot wait for receipt of the needed shapes from its regular source of supply.

Ten Ways to Save Critical Materials in Distribution Systems

Tons of critical materials, particularly copper, can be saved by following these ten principles in installing war-plant power-distribution systems, according to H. V. Erben, manager of General Electric Company's central-station department:

1. Calculate as accurately as possible what the *actual* load will be and design the system to carry only that load—not on the basis of connected load.
2. Keep to the practicable minimum the distance over which the electric power is to be carried.
3. Transmit power at the highest practicable voltages and bring the high-voltage distribution as close to the load as possible.
4. Correct for low power factor at a point as close to the reactive load as possible.
5. Use compact, standard equipments. This not only saves copper, time, and money but also makes possible quick replacement in case of trouble.
6. Arrange layouts to limit circuit-breaker interrupting requirements to the optimum values, thus saving copper in busses and circuit breakers.
7. Use three-phase power transformers wherever feasible.
8. Use forced cooling on power transformers wherever practicable.
9. Select cables with a type of insulation that will permit maximum load per unit of copper.
10. Limit the number of cables per duct bank to the minimum to avoid loss of current-carrying capacity.

WPB Urges Maximum Use of All Available Electric Motors

Extensive use of secondhand electric motors and controls, utilization of full service factor of electric equipment, and design simplification are recommended by the electric motors and control section, general industrial equipment branch, of the War Production Board, as aids in conserving critical materials. Operators who have available secondhand motors or who could make effective use of them should write to the electric motors and control section for assistance in locating or placing such equipment.

With the present wartime material allotment to the electric motor and control industry, it is difficult if not impossible to make deliveries on any orders except those for the armed services and most vital war plants, which utilize about 90 per cent of the industry's production. However, use of secondhand standard electric motors and controls—of which there is an ample supply available in dealers' hands and in manufacturing plants, according to the WPB—would effect immediate delivery of these orders.

According to the electric motors and control section, motors today do not break down because of overheating resulting from overloading, but rather because of mechanical failure. Therefore, where new motors and control are required because of their special characteristics, it suggests that all purchasing agents, engineers, architects, and consultants, concerned with the operation, design, or application of electric motors and control, follow out, to the best of their ability, the following recommendations:

WPB Recommendations

SIZE OF MOTORS

1. In applying motors, determine with maximum possible accuracy the horsepower required. This should be preferably obtained by test, or, in the event that this is impossible, by accurate calculation, or by careful comparison with known power requirements of similar apparatus.

2. When applying open-type a-c continuous rated 40 degrees centigrade motors, where the motor rated voltage is maintained, and where the ambient temperature is usually substantially below 40 degrees centigrade and will only occasionally, or for short periods, equal or slightly exceed 40 degrees centigrade, select the standard horsepower rating which is not substantially more than 80 per cent of the horsepower determined in accordance with recommendation 1.

Example: The required horsepower, as determined in item 1, is 9.3; 80 per cent of 9.3 equals 7.44, so select a standard 7.5-horsepower motor.

3. When applying a motor a-c or d-c rated on a 50 degrees centigrade or 55 degrees centigrade basis, where the motor rated voltage is maintained, and where the ambient temperature is usually substantially below 40 degrees centigrade and will only occasionally or for short periods equal or slightly exceed 40 degrees centigrade, select the standard horsepower rating which is not substantially more than 91 per cent of the horsepower determined in accordance with recommendation 1.

4. After selecting a motor in accordance with recommendations 2 and 3, torque and operating speed should be checked to assure their adequacy.

5. When applying an open-type continuous rated 40 degrees centigrade d-c motor in a location where the ambient temperature is usually substantially below 40 degrees centigrade and will only occasionally or for short periods equal or slightly exceed 40 degrees centigrade, select the standard horsepower rating which is at least 87 per cent of the horsepower determined in accordance with recommendation 1.

SELECTION OF MOTOR TYPES

The type of motor selected shall be of the simplest mechanical and electrical design, which can be used to accomplish economically the purpose for which the motor is purchased. Where operating conditions permit, the motor should meet these specifications:

1. Open type rather than protected.
2. High speed instead of low speed.
3. Single speed rather than multispeed.
4. Single winding rather than two winding where multispeed motors are essential.
5. Alternating current instead of direct current where a-c power is available.
6. Squirrel cage instead of slip ring.
7. Single voltage only.
8. D-c adjustable-speed motors should have a lesser speed range than formerly.

SELECTION OF MOTOR CONTROLLERS

1. The wiring of all controllers should be specified as following the shortest possible route consistent with the avoidance of electrical and mechanical interferences. This will result in approximately 30 per cent reduction in the amount of copper wire used.

2. When controllers are built to order for a specified horsepower, busses, terminals, and wiring should be specified in a size no larger than the minimum required by the application for which the controller is designed.

3. No controllers should be specified of a capacity in excess of the minimum required for the application.

4. No equipment or device should be specified for a controller which can be eliminated without causing severe operating hazards. This equipment includes indicating lamps, special name plates, instruments, test receptacles and jacks, extra terminals, special locks, and items for the improvement of appearance. If specifications are cut to the minimum for successful

operation, many tons of critical material will be saved.

5. Control circuit wiring should be specified in a size no larger than the minimum required to carry the current and to insure reliable and safe operations.

6. Controllers should not be specified with finishes containing critical materials unless these finishes are absolutely necessary to maintain operation of the controller.

7. Color coding of controller wiring should not be specified, unless absolutely necessary. Color-coding specifications force manufacturers to carry larger stocks of wire than necessary if one color wire is used.

8. Control circuit transformers should not be specified, unless the line voltage is higher than 600 volts, or unless suitable pilot devices of adequate voltage rating are not available.

9. Control circuit fuses should not be specified if the control transformers have less than a 2,200-volt primary winding or if the control circuit is direct current.

10. Where full voltage starters are available, and, if motor design will permit, reduced voltage starters should not be specified, unless torque must be limited, or if system capacity makes full voltage starting impossible.

11. If manual controllers of suitable ratings are available, magnetic controllers should not be used, except where pilot devices are essential to the operation controlled or where lack of under voltage protection would result in definite danger to human life.

ELECTRICAL LAYOUTS

1. For new plants or extensions the utlization voltage should be restricted to 440 volts, alternating current, except where motors 100 horsepower and larger are used, in which case the voltage should be 2,200 volts or more. (This means that all integral horsepower a-c motors shall be supplied at 440 volts.)

2. No auxiliary or reserve busses or their attendant equipment should be provided.

3. Network distribution systems should not be used unless they show an over-all saving in critical material.

4. No equipment of any kind should be installed to provide for future loads or extensions.

5. No duplicate feeds or loop feeds should be used if any appreciable amount of material is required above that necessary for a single radial feeder.

6. All busses and feeders should be tapered as to size where long runs are used with loads being taken off along the run.

7. Requirements in all cases should be based on demands after load factor is considered, and all equipment specified so it will be loaded as near name-plate rating as possible.

EQUIPMENT RATINGS NOT TO EXCEED LOAD REQUIREMENTS

1. No electric motor and control should be purchased for any use unless reasonable effort has been made to obtain used or secondhand equipment, unless the maximum number of shifts are used, or unless reasonable effort has been made to adapt to the application idle equipment in the possession of the user.

2. No electric motor and control should be purchased for replacement of existing equipment for reasons of breakdown, damage, or obsolescence, unless reasonable effort is made to keep equipment in operating condition by installation of renewal parts or a reasonable amount of maintenance work.

3. No electric motor or control should be purchased in a size larger or of more complex design and construction than is required by the minimum operating conditions.

Substitute Materials Discussed by Alvah Small Before Contractors

The development of new wartime substitutes to replace critically scarce materials in electrical equipment was the subject of an address by Alvah Small (M'37), president of Underwriters' Laboratories, Inc., before the National Electrical Contractors Association in Bigwin, Ontario, recently.

Naming critical materials that have been restricted by priorities and the possible substitutes being tested to replace them, Mr. Small pointed out that the Underwriters' Laboratories is co-operating by putting into effect necessary changes in its requirements to recognize substitutes promulgated in emergency alternate specifications of the Federal Specifications Board. The provisions of Underwriters' Laboratories' Standards for Electrical Equipment have been identical with those of the United States FSB for like products for several years, he said. The substance of Mr. Small's address is reflected in the following paragraphs.

Demands for the consideration of substitutes were made of Underwriters' Laboratories, Inc., as early as the spring of 1941. Priorities controlling or limiting the use of zinc as a corrosion protective material required action with respect to coatings of raceways and of outlet and distribution-center hardware. Existing requirements were relaxed for the duration, so as to recognize enamel and paint finishes or to accept lesser thicknesses of zinc for coatings. Next, limitations on the use of cadmium and chromium made it necessary to accept, for the duration, phosphate treatments of the surface finishes of iron or steel parts; in most cases as a first or preparedness step for a final lacquered or paint finish, in other cases in preparation for the thinnest possible electrodeposited metallic finish.

MANY FSB AND UNDERWRITERS' REQUIREMENTS IDENTICAL

Always a large user of building materials and equipment, the United States early in 1941, perhaps even previously, became the biggest consumer of them. Consequently, the Underwriters' Laboratories practice of changing its requirements to meet the needs of the FSB was a practical plan of procedure, because the government had become the building industry's biggest customer, and because, in practically every case, the Federal Specifications Board determined upon changes that it announced only after conferences with the industry. Electrical equipment is naturally included in the catalog of Federal Specifications so modified. To some extent this was a "thoroughfare" routine, and Federal Specifications Board has adopted and announced changes that had already been published by Underwriters' Laboratories after being determined according to its "open-forum" program. Many requirements identical with those of the Underwriters' Laboratories, are merely a reference to the chapter and verse of an Underwriters' Laboratories' Standard.

The classification of aluminum as a critical material had early and due effect upon Underwriters' Laboratories' requirements because of changes demanded by the Office of Production Management in approved formulas for zinc-base die castings. For a while it seemed doubtful if recognition of these useful parts could be continued while the attainment of even minimum requirements for safety in performance was secured. It developed, however, that steam-bath tests provided an acceptable control while this difficulty continued. Many instances of prompt acceptance of substitutes for sheet aluminum are on record. Cotton-base phenolic composition for blades of electric fans is one of these instances.

The shortage in tin, particularly since Pearl Harbor and Singapore, required consideration of lower grades of brass in various parts and uses and promoted the use of a previously recognized substitute for the coating of rubber-insulated copper conductors in wires and cables. Mixtures for solder with lower tin content are recognized for many applications.

The limited supply of nickel made this metal a critical material early in the defense period. Once it was doubtful if nickel would be allowed for use in the bimetal elements that have so many safeguarding applications for temperature control, not only in electrical services but in many other fields. Its use in heating elements seems to be out in any event, but, fortunately, up until now, ways have been found to permit its use for bimetal elements of controls.

Plastics of various types and kinds were well established in electrical and other fields of application long before the preparedness and defense-program periods. In 1938–39 the thermoplastic type of synthetic insulation was developed and given generous recognition for conductor coverings. Unfortunately, up until now, priorities have limited its general availability as a wartime substitute.

More than a year ago requests were first received that brass-plated steel be recognized instead of solid brass as a material for the wire-binding screws in lampholders, switches, and receptacles.

The senior electrical contractors will recall that, because of the copper shortage, steel parts, copper- or brass-plated, were accepted for panelboards, panelboard switches, and other products during World War I. Experiences, due to corrosion, heating, and maintenance troubles, makes one understand the reluctance of the laboratories to repeat this step and the troubles of the previous emergency. Recently it became necessary to take this step in order to assist in the conservation of copper and copper-bearing alloys, and now emergency alternate standards or requirements are in effect permitting the substitution of steel, plated or otherwise protected against corrosion, in the assembly of current-carrying appliances unless the actual part is involved in the making and/or breaking of a circuit. In addition, the Laboratories is conducting a research to determine what will be the performance of iron or steel, plain or plated, when substituted for parts actually involved in the current-interrupting function. It may be that the corrosion protection accomplished on stamped steel parts will function as desired until replacement can be made after victory. Such replacements will probably be required, particularly in seacoast areas within shorter periods, so that it may be wise to plan for replacements before the end of the war.

In the interval between Pearl Harbor and the fall of Singapore, requests were made for the lowering of Standards for rubber compounds in building wire insulation. After Singapore it was, of course, obvious that it had become the duty of everyone to conserve rubber in every possible way. Underwriters' Laboratories' requirements for the performance of rubber insulations in the oxygen-bomb test were modified to permit the use of much less new crude rubber in compounding.

Shortly after Singapore, the War Production Board found it necessary to conserve rubber by refusing permission for its use in the all-rubber type *POSJ* flexible cords employed with ordinary types of portable appliances. The type *PO*-64 flexible cord now substituted and recognized, in view of this limitation order, has perhaps the minimum positive value of factor of safety as well as of appearance and of general consumer and user satisfaction.

GUIDED BY NATIONAL ELECTRICAL CODE

In considering proposed substitutes for electrical goods, Underwriters' Laboratories is guided by the provisions of article 110—general—of the National Electrical Code. Sections 1113–1117 inclusive, in particular, apply; with section 1115 as the lead-off item of the group:

> "1115. General Plan of Investigation. Materials devices, fittings, apparatus, and appliances designed for use under this code shall be judged chiefly with reference to the following considerations which also determine the classification by types, sizes, voltages, current capacities, and specific uses:
>
> (*a*). Suitability for installation and use in conformity with the provisions of this code.
>
> (*b*). Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.
>
> (*c*). Electrical insulation.
>
> (*d*). Heating effects under normal conditions of use and also under abnormal conditions liable to arise in service.
>
> (*e*). Arcing effects."

Changes that have been made in the National Electrical Code are reflected in the operations of Underwriters' Laboratories. For example, the new so-called type *EI* building wire is being accepted in nonmetallic sheathed cable, and the type *EI* wire itself is to be labeled as an emergency for-the-duration substitute for rubber-covered wires in exposed dry locations.

Donald Nelson's "bare-bones" policy that, for the duration, construction of new facilities be "of the cheapest temporary character" with structural stability only sufficient to meet the needs of the service which the structure is to fulfill during the period of its contemplated war use is a challenge to us to effect the maximum economies of materials and of manpower, and, at the same time, where safeguarding life, property, products, and material is involved, not to lower our standards below the minimum of normal times. To preserve at least these minimum standards of safety is the Underwriters' Laboratories' objective in the consideration of wartime substitutes.

Industry Urged to Plan for Man-Power Replacements

Advising industry to plan now for the loss of employees through the increasing need for military man power in the United States, Major General Lewis B. Hershey, director of Selective Service, pointed out in a recent statement that every employer should make a prompt inventory, appraisal, and analysis of the man power in his own plant. "In order to keep production going and at the same time furnish men for the armed forces, industry should now establish an orderly replacement program," he said. Essential substance of his statement follows.

In order to secure temporary deferments for essential men while training women, young men, older men, men physically handicapped, or those with a high degree of dependency, the employer should know the fundamental principles in the operation of his local Selective Service Board. Each employer should know how many men on his pay roll are between the ages of 20 and 45. He should investigate the classification of every one of those men. On the basis of such an inventory he should prepare to train men for the replacement of those who must necessarily enter the armed forces in order that the United States have the sort of army which can win the war.

DEFERMENTS TEMPORARY

Deferments, granted so that employers may train women or men not liable to early induction, are temporary deferments; they cannot exceed six months and in many cases may be for only thirty, sixty, or ninety days. The United States Army today has to train a bomber pilot within a period of eight months to operate a very technical machine with an instrument board which puzzles an expert. Industry, therefore, should not assume that it can take two or three years to train men for industrial tasks not nearly so complicated.

The fundamental purpose of every deferment of a registrant is to allow an employer to train a replacement worker. Only in rare instances can an employer expect to have temporary deferments continued for more than the six months period. This is possible only in cases where an abnormally long period of training is required for a replacement.

Employers may seek the deferment of their necessary men with or without their consent by the method outlined as follows.

On page 3 of the Selective Service questionnaire (form 40) which is sent to each registrant before he is classified, is the following:

> *Instructions.* If your employer believes that you are a necessary man in a necessary occupation, it is his duty to fill out form 42A requesting your deferment. You may also attach to this page any further statement by yourself which you think the local board should consider in determining your classification. Such statement will then become a part of the questionnaire.

This is on all the questionnaires distributed during the past six months. The fact that the Selective Service system now specifically mentions the filing of form 42A as the manufacturers' duty, is a clear indication of the Selective Service system view on the responsibility of each employer in this matter. The employer can secure form 42A at the local board which will consider the employer's request when the form is properly filled out and signed. Only when an employee is working in a critical occupation within an essential industry should form 42A be filed for his occupational deferment.

If such a request should be denied because the man, after consideration of the claims offered for him, is thought to be not indispensable to the company's operation, and is needed more urgently in the armed services, the local board will inform the employer of its refusal to give an occupational deferment. The local board does this by sending to the employer, at the same time it notifies the registrant of his classification, form 59.

APPEAL POSSIBLE

There are ten days after form 59 is mailed by the local board to the employer during which the employer can appeal the registrant's case. The registrant will not be ordered to report for induction during this ten-day period.

In order to make an appeal, the employer simply has to sign his name to form 59 which he has received, and return it to the local board. In case the form 59 is not received from the local board, any written request is considered a valid appeal. When form 59 is returned by the employer the appeal procedure becomes automatic. All necessary forms are available at the local board in the employer's immediate vicinity or at the office of the state director of Selective Service.

If the local board and the appeal board deny the appeal for the occupational deferment of a key man, the employer may then bring the matter to the attention of the state director at the State Selective Service headquarters, with the request that the case be reopened or appealed by him to the president.

THE EMPLOYER'S DUTY

A double duty rests upon the employer. He should personally know what his manpower situation is. He should not allow a minor employee to decide whether or not he is necessary in industry. The employer who delegates the task of filing a request for deferment to a clerk, the executive who does not make a complete inventory of his whole plant today, is negligent. Likewise, the employer who files requests for deferment of men who can be replaced by women or others, is keeping reinforcements out of an army which is battling for us all. The employer engaged in essential war production who has been required to expand his plant and who then fails to request deferment for his key men is also negligent. Employers are requested not to ask for deferments for any men who can be replaced by training another individual not likely to be eligible soon for service in the armed forces. On the other hand, employers should make requests for deferment for any man whose immediate going into the armed services would retard production of vital war material or other services essential to the war effort, or who is needed to maintain national health or safety.

Power Units Built for Synthetic Rubber Plants

Electrical apparatus for plants which will convert petroleum and alcohol derivatives into synthetic rubber, including steam turbine generators, are reported to be under construction by both General Electric and Westinghouse Electric and Manufacturing Companies. The abundance of high-pressure steam required for the production of butadiene and styrene, principal constituents of Buna *S* rubber, will enable the new chemical plants to generate their own electric power as a by-product. The steam will be used first to drive the turbine generators and then in the chemical processes.

Steam at a pressure of 750 to 850 pounds per square inch will pass from boilers to a steam turbine which will be coupled to an electric generator. Leaving the turbine at about 175 pounds pressure, the steam will then be used in the plants' chemical processes.

Part of the electricity will supply the motors and lights in the chemical plants, as well as in the adjacent co-polymerization plants in which the chemicals are combined to make rubber. Since the power generated will be much more than required by the chemical and rubber plants, the surplus will be diverted into regular public utility lines to help supply other war industries.

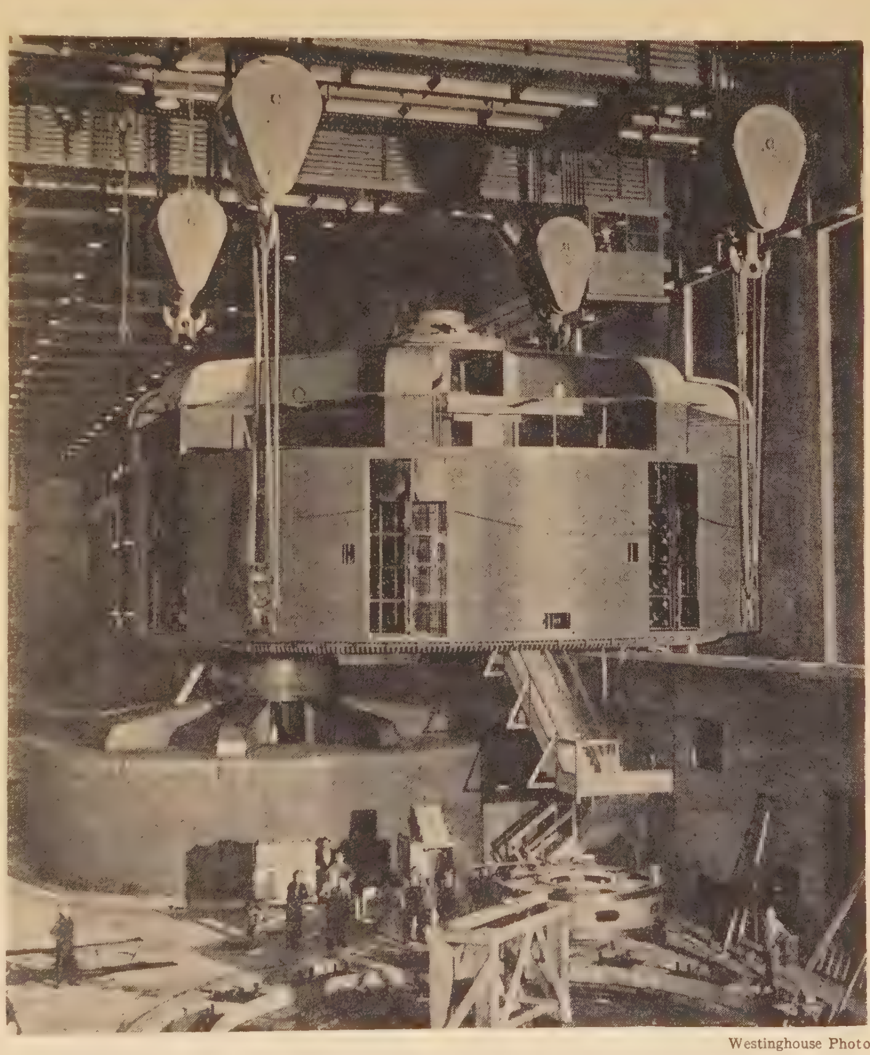
New Electric-Power Capacity Curtailed to 5,500,000 Kw

New power-generating capacity for completion in 1942, 1943, and to a limited extent early in 1944 has been scaled down to 5,500,000 kw, as opposed to the previous 9,600,000-kw program extending through 1945, according to latest revisions of priority ratings announced by the War Production Board. The aim of these new revisions is to convert manufacturing facilities to war production as quickly as possible, by rushing to early completion all utility projects essential to the war program, and by preventing the remaining projects from competing with military needs for critical materials. This new ruling means the halting of some projects now in construction and the continuance of others on a low-rated basis only. The decisions followed a comprehensive review begun last spring of the electric-utility-construction program from the viewpoint of the power-supply and requirements situation.

Of the 5,500,000 kw to be provided, 3,400,000 kw is in private utility projects, mostly steam, and 2,100,000 kw in public projects, mostly hydroelectric. Projects which have been given the higher priorities are designed to assure supply for war and indirect war production as now planned, with a small margin of capacity to provide for possible additional war production not now included in the munitions program. Assignment of units has been made on the basis of the needs of reasonably unified areas rather than strictly by systems.

Projects totaling 1,890,000 kw—previously scheduled for installation in 1943–45 as part of the program for Federal generating projects—are being reduced to low ratings, or are being held to their present low-rated or nonrated status. Work on low-rated projects may be continued, but only to the extent that it does not compete

More Power for War Plants



Westinghouse Photo

A 108,000-kw waterwheel generator, weighing 1,000 tons and measuring 45 feet in diameter and 24 feet high, being lowered into position in the powerhouse at Grand Coulee Dam, Wash.

for critical materials and equipment needed for direct war uses. For the most part, these Federal projects are hydroelectric developments.

ELECTRIC-SYSTEM EXPANSION ALSO CURTAILED

Further construction of electric power and light projects permitted under prior authorization with respect to projects 40 per cent complete on December 5, 1941, has been halted by WPB. The action, however, does not affect the construction of important war projects that have been or may be specifically authorized by WPB.

The new ruling removes authority to complete construction projects 40 per cent complete on December 5, and provides that there may be no additions or expansions to electric systems except as specifically authorized by the Director General for Operations of the WPB. It applies alike to both public and private utilities.

Manpower Commission Reports on War Use of Colleges

A report on recent developments in the utilization of colleges and universities in furthering the war effort was released August 28 by the War Manpower Commission. The report was prepared by the WMC special committee on the utilization of colleges and universities for the purposes of the war; personnel of this committee consists of: Edward C. Elliot, president, Purdue University, chairman; James B. Forrestal, Undersecretary of the Navy, Major General Lewis B. Hershey, director, Selective Service, G. H. Dorr, special assistant to the Secretary of War, Arthur S. Fleming, Civil Service Commission, and Wendell Lund, labor supply division, War Production Board.

Among the various items considered by the committee in preparing the report was the official statement of the Second Baltimore Conference of officers of institutions and organizations of higher learning, held July 15–16, 1942 (*EE Sept. '42, p. 490*). Essential substance of the report follows.

The members of the committee, mindful of the patriotic anxiety of the leaders of higher educational institutions state that these institutions shall have opportunity completely to perform their duties at this critical time. Furthermore, the members of the committee are confident that these institutions may be relied upon to respond willingly and energetically to the realistic needs growing out of the grim urgency of the war situation.

The utilization of the resources of materials and man-power of the United States for the armed services, war production, and for supporting war efforts depends on the immediate and developing war situation. Plans which are made today for the use of these resources must be flexible enough to meet the changing requirements of the war program.

The principal resources of colleges and universities for war purposes are their trained faculties and their physical facilities. The use of these resources will be determined by and should be adapted to the military needs of the nation.

All branches of the armed services are now using certain of the resources of the colleges and universities with the active co-operation of the institutions. The nature and the extent of this use must necessarily depend upon the need in the conduct of the war.

Any adequate plan designed to make effective use of colleges, universities, professional, and technical schools must be based upon the following considerations:

1. All students, men and women, must be preparing themselves for active and competent participation in the war effort and supporting civilian activities. This basic proposition will, of course, be accepted and understood by the institutions, by the students, and by the general public.

2. All able-bodied male students are destined for the armed forces. The responsibility for determining the specific training for such students is a function of the United States Army and Navy.

3. For those students, men and women, who are not to serve in the armed forces, there should be developed through the War Manpower Commission plans of guidance which will help the students to determine where they can make the most effective contribution to the war effort, including essential supporting activities. The War Manpower Commission should also make plans for the instruction of those for whom further training is necessary to enable them according to their qualifications to make their most needed contributions to the support of the armed forces.

4. Any plan for student war training must take into consideration the possibility that the Selective Service Act may be amended so as to lower the age of liability for service to 18 years.

5. All those colleges, universities, professional, and technical schools assuming direct responsibility for the training of students for war purposes must be prepared to readjust their instructional programs and procedures so as to enable them promptly and efficiently to meet the new and varying needs of the war.

6. Throughout the preparation for wartime services, provision should be made for securing the complete physical fitness of students.

7. In order to avoid misunderstanding, students should recognize that the exigencies of the war do not make it possible to assure any student that he will be permitted to remain in the institution for any specified period of time. Furthermore, it should be recognized that it will not be possible prior to the opening of the academic year 1942–43 to formulate the details of some of the plans for the utilization of institutions nor to provide for the implementation of such plans.

8. The above plans for the war training of students do not contemplate any Federal subsidy to institutions.

9. To qualified students whose additional training is required for the war effort, financial assistance should be made available to permit them to receive that training.

10. The division of professional and technical personnel of the War Manpower Commission will proceed immediately to function as a central agency to assemble information from the government departments and higher educational institutions concerned and confer with them as to plans and procedures for the utilization of the facilities of the institutions and the adjustment of their programs for effective participation in the war effort.

Technical-Personnel Requirements to Be Checked by USES

Business establishments engaged in war production are going to be told within the next few weeks where and how they can obtain chemists, engineers, metallurgists, and other professional and scientifically trained men, Paul V. McNutt, chairman of the War Manpower Commission announced August 10. He said that representatives of the United States Employment Service had been instructed to find out how many employees of this type war-production plants will require before the end of the year and during 1943.

With this information in hand the USES, Mr. McNutt explained, can draw upon the country's largest registration of technically trained persons, the National Roster of Scientific and Professional Personnel. This roster, to which are now being added the names of the scientifically and professionally trained persons who have registered for military service, has been placed under the direction of the War Manpower Commission.

President of GE Named WPB Vice-Chairman

Charles E. Wilson, president of the General Electric Company, Schenectady, N. Y., has resigned to become vice-chairman of the War Production Board. In that capacity he will act as chairman of the newly organized production executive committee, which is composed of officials of the Army, Navy, and Maritime Commission and which is to have control of the production of military supplies. Mr. Wilson is succeeded as president of the General Electric Company by Gerard Swope (F'22) former honorary president (see Personal item on page 532 of this issue).

In the absence of Philip D. Reed, chairman of the board of directors of the General Electric Company, who is also in the service of the United States Government, Owen D. Young, honorary chairman, has been appointed acting chairman.

New WPB Director of Operations Announced. Ernest Kanzler, former deputy chairman on program progress, War Production Board, has been appointed director of general operations, according to Donald M. Nelson, chairman. Mr. Kanzler, who will have under his supervision all WPB operations carried out through industry and materials branches, succeeds Amory Houghton. Prior to his affiliation with the WPB, he was president of the Universal Credit Corporation, Detroit, Mich., which he founded in 1928, and had served for many years as vice-president in charge of production for the Ford Motor Company. In January 1942, he became chief of the WPB automotive branch with headquarters in Detroit, and in March 1942 he was appointed regional director of the WPB in Detroit. He was in direct charge of WPB activities in connection with conversion of the automotive industry.

Salvage Manual Available. A "Salvage and Scrap Material Manual for the Utilities" has been prepared by the utility unit, industrial salvage section, conservation division of the War Production Board, for the information and use of utilities in their salvaging and scrap operations. It was prepared from procedures furnished by several utility companies and is a compilation of information on methods of salvaging materials for reuse and handling scrap. The manual contains an alphabetical listing of salvageable materials with descriptions of rehabilitation procedures and an assembly of scrap-material specifications.

INDUSTRY• • • • •

Positions to Be Filled Through Civil Service Examinations

Notice of the following positions, which will be filled through civil service examinations, is published here as a service to members of the Institute. Application forms and full information as to requirements for examinations may be obtained from the secretary of the Board of the United States Civil Service Examiners at any first- or second-class post office, or the United States Civil Service Commission, Washington, D.C.

Junior Physicist. $2,000 a year salary. No age limits. To qualify for the position, applicants must already have completed, or complete within six months after filing applications, a four-year college course including 18 semester hours in physics. Applications will continue to be accepted until the needs of the service have been met. No written tests are required.

Technical Assistant. Salaries range from $1,440 to $1,800 a year. The examination contains three optional branches: engineering, metallurgy, and physics. To qualify for the $1,800 positions, the applicant must have completed three years of college study. For the $1,600 positions, two years of college study is prescribed, and for the $1,440 positions, one year of college study is prescribed. Provision is made for the substitution of appropriate war-training courses for college hours in any optional branch. No written tests are required. Applications are not desired from persons engaged in war work unless a change of position would result in the utilization of higher skills possessed by the worker.

Westinghouse Launches New Lighting Activity. Application of recently developed light sources to the expanding lighting needs of the nation will be studied by the newly created illuminating engineering department of the Westinghouse Lamp Division, which will be headed by D. W. Atwater (A'34) former manager of commercial engineering (see page 531 of this issue). The new organization will plan for postwar as well as present expansion in the use of fluorescent, mercury vapor, and other light sources.

1942 Power Show Location Changed. The 15th National Exposition of Power and Mechanical Engineering, previously scheduled for Grand Central Palace, November 30 to December 5, 1942 (*see EE, Sept. '42, p. 493*), is to be held at Madison Square Garden, November 30 to December 4, according to a recent announcement. The change was made necessary by the fact that the United States Army has taken over the exposition floors for the duration of the war for use as an induction center.

OTHER SOCIETIES•

SPEE Awards Lamme Medal

The Society for the Promotion of Engineering Education has awarded the Lamme Medal for Achievement in Engineering Education to Roy A. Seaton, dean of the division of engineering and architecture, and director of the engineering experiment station, Kansas State College, Manhattan, Kansas, "for his leadership in engineering education . . . . for his service to his country through the development of emergency training in engineering in time of war, and for his demonstration of the value of basic engineering training in the solution of large social and economic problems." He has been associated with Kansas State College in educational and administrative work since 1904, with the exception of three short leaves. He has been an active member of the SPEE and has served as its representative on the governing board of the Engineering Council for Professional Development since 1937.

NRC Insulation Conference Plans Held in Abeyance

No plans for the annual meeting of the Conference on Electrical Insulation of the National Research Council are being made for the immediate future, according to a recent announcement by W. F. Davidson, chairman of the NRC division of engineering and industrial research. It is possible, however, that the committee on physics or the committee on chemistry may schedule some meetings with the conventions of the American Physical Society and the American Chemical Society.

Future Meetings of Other Societies

American Chemical Society. National Chemical Exposition and National Industrial Chemical Conference, November 17–21, 1942, Chicago, Ill.

American Institute of Chemical Engineers. 35th annual meeting, November 16–18, 1942, Cincinnati, Ohio.

American Institute of Mining and Metallurgical Engineers. Regional meeting, October 12–17, 1942, Los Angeles, Calif.

American Physical Society. 251st meeting, November 27–28, 1942, Chicago, Ill.

American Society of Mechanical Engineers. Fall meeting, October 12–14, 1942, Rochester, N. Y.; annual meeting, November 30–December 4, 1942, New York, N. Y.

American Society of Tool Engineers. Semiannual meeting, October 16–17, 1942, Springfield, Mass.

American Welding Society. 23d annual meeting, October 12–15, 1942, Detroit, Mich.

Electrochemical Society. Fall meeting, October 7–10, 1942, Detroit, Mich.

National Electrical Manufacturers Association. Annual meeting, October 26–30, 1942, New York, N. Y.

National Safety Council. 31st national safety congress and exposition, October 27–29, 1942, Chicago, Ill.

Pacific Coast Electrical Association. Bus development and administrative sections, October 22–3, 1942, Fresno, Calif.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without letter, the other lettered. Captions should be supplied for all illustrations.

Cover Photograph

To the Editor:

That transmission lines of the Pacific Northwest have their lightning troubles is emphasized in the accompanying photograph [reproduced on the cover of this issue]. This picture was taken in early July, 1942, near the Bonneville-Grand Coulee 230-kv lines. The storm was traveling toward the point of observation, the farthest stroke having occurred a few seconds before the near one. Heavy rain fell in the vicinity of the near stroke and is discernible in the light rays emanating from the cloud. Both strokes occurred some distance behind the lines as is evident from the silhouetted towers. The peculiar appearance of the near stroke passing through the tower, and between the observer and the lines of the near circuit, is due to film halation. No outages occurred from these strokes. The photograph contains some points of interest. In particular, it indicates that the near stroke contains a multiplicity of streamers, while there are only two partially discernible in the farther one. The fact that lightning strokes may or may not contain branching has been commented upon in various publications. But aside from showing that the difference is not a function of polarity, the phenomenon has not been very well explained. It would seem that if we can formulate a reasonable explanation for branching or for not branching, we may have a more definite clue to the formation and nature of lightning charges. The observations which follow are submitted as possible clues, with the hope that other contributions may lead to an ultimate understanding of the phenomena.

If the mechanism of atmospheric charges can be likened to static electricity as we know it on a smaller scale, we can assume that (for discharges to earth) the cloud and earth form electrodes about a dielectric field wherein the energy is stored prior to discharge. The cloud is not comparable to a metallic electrode, and some investigators believe that different parts of the cloud are charged to opposite polarities, which must presuppose that the cloud acts as a dielectric medium within itself as well as an electrode for the discharge to ground. If the energy storage prior to a discharge is in the dielectric medium between the electrodes, as we would normally suppose, the formation of streamers due to breakdown within the dielectric is not difficult to understand. But if the reasoning which makes streamers understandable is applied to lightning phenomena in general, it is difficult to explain the strokes without streamers, or those with only occasional streamers, which from visual observations are probably the most common.

There is a difference between natural and laboratory lightning that may be comparable. In the laboratory, the energy storage is in a dielectric medium that does not break down at flashover. The arc takes place between electrodes that are apart from the capacitors wherein the charge is stored. Usually, photographs of these discharges have no branching, although frequently additional streamers emanate from the electrodes, and occasionally the arcs contain loops.

Branching in both directions is shown in a laboratory discharge ("Lightning—Progress in Lightning Research in the Field and in the Laboratory," by F. W. Peek, Jr., AIEE *Transactions*, volume 48, 1929, pages 436–48) made with glass-plate *capacitors* charged without rectifiers from an alternating-current source. This discharge occurred in an area that may have been within a charged field prior to flashover.

High-frequency oscillator (Tesla coil) discharges contain a multiplicity of branches, or at least they appear so. They also emanate from a single electrode and do not necessarily terminate on another electrode. This discharge is oscillatory, and therefore both polarities are involved in the phenomenon.

H. L. RORDEN (M'36)

(Bonneville Power Administration, Portland, Oreg.)

Balancing Three-Phase Water-Rheostat Loads

To the Editor:

Much difficulty is usually encountered in endeavoring to balance three-phase water-rheostat loads during student laboratory experiments. However, there is a very systematic method of achieving a three-phase balance without approximations. The procedure is direct and simple. A thorough search in handbooks and textbooks on laboratory procedure and an inquiry among the faculty at the California Institute of Technology, seem to indicate, however, that this system is not generally known.

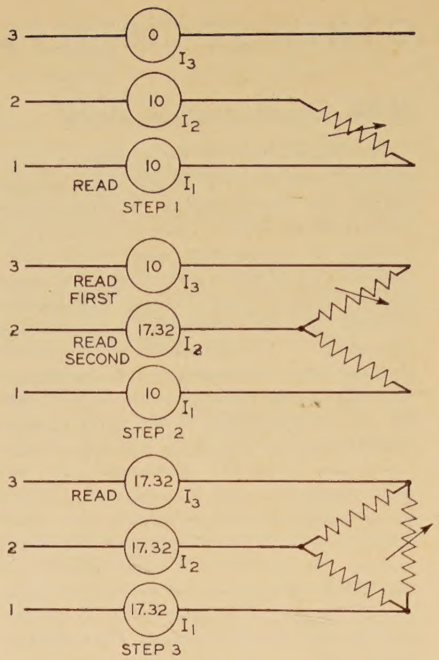


Figure 1. Method of balancing three-phase water rheostats

Step 1—Adjust load between lines 1 and 2 till meter reads 10 amperes

Step 2—Adjust load between lines 2 and 3 till $I_3 = I_1$. *Read* I_2

Step 3—Adjust load between lines 3 and 1 till $I_3 = I_2$. *Load is then balanced*

The method is best illustrated by a numerical example. If we want a balanced three-phase load of 17.32 amperes per line, then, referring to the accompanying diagram, have all rheostats completely out, and:

Step 1. Cut in water rheostat between lines 1 and 2 until the ammeter in line 1 reads $17.32/\sqrt{3}$ or 10 amperes. The ammeter in line 2 then also reads 10 amperes.

Step 2. Cut in water rheostat between lines 2 and 3 until the ammeter in line 3 reads 10 amperes. The current in line 1 is unaltered, and line 2 now carries $10\sqrt{3}$ or 17.32 amperes.

Step 3. Cut in water rheostat between lines 1 and 3 until the ammeter in line 3 reads 17.32 amperes. The current in line 2 is not altered by this adjustment, because of the previous balance existing between lines 1–2 and 2–3. Line 1 now reads 17.32 amperes, and the load is completely balanced.

Recapitulating, to get a balanced load of I amperes with no load on originally, put $I/\sqrt{3}$ amperes onto lines 1 and 2. Then, adjust the load between lines 2 and 3 until $I/\sqrt{3}$ flows in line 3. Adjusting the load between lines 1 and 3 until I amperes flows in line 3 then produces the balanced three-phase load desired.

If a dynamometer board is utilized, so that one ammeter is used for all three currents, no complication is introduced, and, furthermore, extreme accuracy in balancing is obtainable.

It is to be emphasized that all load must be off the lines before the balancing process is started. To increase or decrease the balanced load, it is a simple matter to start all over again; if this is not desired, proceeding in the same systematic manner will produce a different balanced load; that is, altering the load between lines 1–2, then altering load 2–3 till $I_3 = I_1$, and finally adjusting load 3–1 till $I_3 = I_2$. This method is just as applicable to nonunity-power-factor loads.

In case accidental unbalance occurs, it is best to start all over again.

If metal resistor banks are available for loads, this method is not needed. However, as much as one hour of a three-hour experiment has been saved when using this systematic method, rather than the usual hit-or-miss procedure, for balancing water rheostats.

VICTOR WOUK

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Two Network Theorems

To the Editor:

In the April 1942 issue of *Electrical Engineering*, Henry Ling demonstrates two network theorems (Letter to the Editor, pages 225–7). Both of these are special cases of a more general network theorem discussed by me in the *Proceedings* of the Institute of Radio Engineers, volume 28, September 1940.

Refer to Figure 1. The impedances Z_1, Z_2, . . Z_n terminate in a common junction 0′. The opposite ends of these impedances are numbered 1, 2 . . . n, whereas 0 is any other point in the network. In the article referred to it is demonstrated that

$$V_{00'} = \frac{\sum_{s=1}^{n} V_{0s} Y_s}{\sum_{s=1}^{n} Y_s} \tag{1}$$

where $V_{00'}$ is the voltage drop from 0 to 0′, V_{0s} is the voltage drop from 0 to s and $Y_s = 1/Z_s$ is the admittance corresponding to the sth impedance.

If between 0 and the kth impedance there

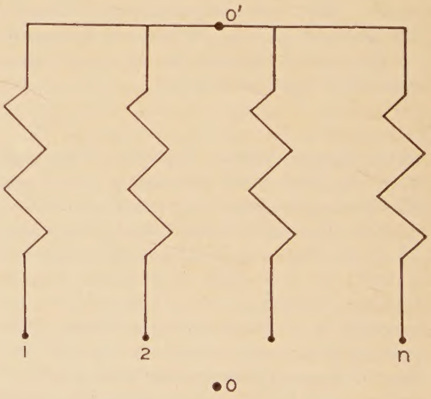

Figure 1

is a generator whose voltage drop is V_{0k} whereas the terminals 1, 2 . . . n (except k) are directly connected to 0, then equation 1 becomes

$$V_{00'}=\frac{V_{0k}Y_k}{\sum\limits_{s=1}^{n} Y_s} \qquad (2)$$

This is Ling's first theorem.

In the more general case (with none of the voltages V_{0s} equal to zero) then the current in the kth branch is

$$I_{0'k}=\frac{V_{0'k}}{Z_k}=Y_k(V_{0'0}+V_{0k})=Y_k(V_{0k}-V_{00'})$$

or

$$I_{0'k}=Y_kV_{0k}-Y_k\ \frac{\Sigma V_{0s}Y_s}{\Sigma Y_s} \qquad (3)$$

where use was made of equation 1. This is Ling's second theorem. The notation used here differs from that used by Ling, who introduces a "dropping factor" defined by

$$D_k=\frac{Z}{Z_k}=\frac{1}{Z_kY}=\frac{Y_k}{\sum\limits_{s=1}^{n}Y_s} \qquad (4)$$

and "the short-circuit current of the source" in the kth branch as

$$I_k=\frac{V_{0k}}{Z_k}=V_{0k}Y_k \qquad (5)$$

Using equations 4 and 5, the results 2 and 3 may be written as

$$V_{00'}=D_kV_{0k} \qquad (6)$$

and

$$I_{0'k}=I_k-D_k\sum_{s=1}^{n} I_s \qquad (7)$$

Equations 6 and 7 are forms used by Ling.

JACOB MILLMAN (A'37)

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A Peace Worth Fighting For

To the Editor:

President William E. Wickenden's address on "A Peace Worth Fighting For" (*EE, Mar. '42, p. 113–19*) and the comments upon it in Professor C. M. Jansky's letter published on pages 386–7 of the July 1942 issue of *Electrical Engineering* are most illuminating.

We can all agree to the statement that the only solution to the problem of German revolt against the world, is the transformation of the German outlook on all the essential questions that have faced humanity for so many centuries.

While undoubtedly there has been a recrudescence of German militarism in the last 80 years, the German people and their predecessors the Huns, have been militaristic for about 2,000 years, or perhaps longer. Is it not worthwhile to try to discover the reason for the reappearance of this militarism 80 years ago?

The date coincides almost exactly with the publication in 1859 of Darwin's "The Origin of Species." It is a strange thing to say but I am convinced that Darwin, one of the greatest scientists the world has ever known, is largely to blame for this destructive attitude of the German people.

Since the beginning of what we call Western civilization and particularly since the beginning of Christianity, the masses have had their religion, to curb their passions, limit their injustices, control their greed, lust, and anger—the primary causes of war. With the publication and development of the Darwinian theory with its insistence on the natural evolution of man and its discard of the Biblical story of creation, and with the gradual seepage of the theory of evolution and particularly of the survival of the fittest through the greater part of the masses (and the Germans have understood the survival of the fittest as the survival of the strongest) the power of religion has been weakened, that is, of religion as generally understood. This, of course, is an entirely erroneous understanding of Darwin, and of the many others that have advanced the study of evolution, including Bergson and his "Creative Evolution." Up to the present, really nothing has arisen to take the place, in the hearts of the great masses, of the hold that Christianity, whether Protestant or Roman Catholic, Judaism, and the other religions had. Some attempts have been made by the "Ethical Culture" societies founded by Felix Adler, the advanced Unitarian, and the Humanist movement; but none of these has been able to make any important headway against the old established religions.

What I mean to say is that until we are able to get some popular religion that will catch the hearts of the masses and which they can understand and cling to, or to put it in another way, until the differences between science and religion disappear and the people understand that it is not necessary to believe in a hereafter or in resurrection, to be good, progress along ethical lines will be difficult.

To connect this with the present problem of the German revolt and the problem of what to do when victory comes to the democracies, as it must come, seems to lead to the conclusion that the only way to control German militarism is to leave an army of occupation in Germany for at least three generations, or until such time as the democratic nations are fully convinced that the Germans, and especially the German youth, have become religious enough to be trusted to follow the principles of the Sermon on the Mount and to have faith in the high destiny of humanity, when greed, lust, and cruelty will have disappeared or become less prevalent, and the world will be ruled mainly by honesty, justice, benevolence, and magnanimity.

It is true that a great many of the rest of us have not yet reached that desirable condition, but at least we have discarded inordinate cruelty, mass murder, and incredible treachery in the relations between governments, even if in our relations with each other the principles of greed, selfishness, and cruelty still rule pretty well all over. At least let us be sure that governments, in their relations with each other, will reach some degree of fair dealing and of understanding of the sanctity of international agreement.

G. LOBO (F'12)

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A Suggestion for Saving Power

To the Editor:

The technical press, many of the newspapers, and all of the government officials vitally concerned are stressing the fact that there is an impending power shortage in the United States. The solution proposed is the installation of additional generating capacity either through public finances or by means of private capital.

It is believed, however, that there are ways and means of increasing the supply of power by decreasing losses on transmission and distribution circuits. It is a natural thing for losses to take place on electrical circuits, but it is absolutely unnatural and abnormal where the losses equal or exceed 40 per cent of the power that is usefully employed. We have such a situation existing in series street lighting circuits today.

A rate case was recently completed before the New York Public Service Commission which involved the reasonableness of the street lighting rates in the Village of Roslyn in Nassau County, Long Island, N. Y. Current in this area is supplied by the Long Island Lighting Company. During the course of the hearings one of the company experts revealed the fact that 44 per cent of the total energy generated for street lighting purposes in the territory of the company is lost, wasted, or otherwise unaccounted for. This dreadful inefficiency exists only in series circuits.

The series street lighting circuit today is a direct descendant or relic of case 10,388—Roslyn versus the Long Island Lighting Company—and the original lighting system of the early days when streets and roads were illuminated with carbon-arc lights which were almost invariably connected in a series circuit. When incandescent lamps gradually replaced the carbon-arc lamp it seemed desirable to retain as much of the original equipment as possible. As a result we have the present highly inefficient series street lighting circuits in use today. To add to the unnatural condition, the cost of a series street lighting transformer is more than that of the ordinary distribution transformer. Based on figures developed during the hearing, it was shown that a series street lighting circuit required an investment of \$96 per kw for transformer capacity as compared with a cost of \$12.20 per kw if a multiple system was substituted. The reliability of the series circuit is, of course, considerably less than the reliability of an average multiple circuit. In the case of a wire breakage in a series circuit, the entire circuit is put out of use. A broken wire in the multiple circuit merely affects the lamp or lamps that are on that particular portion of the circuit.

Losses in multiple circuits hardly ever exceed 15 per cent to 18 per cent and it would seem incumbent upon the electrical industry, both the manufacturers and the utilities, that considerable thought be given to this situation of extremely high losses on series street lighting circuits in use today. In some isolated instances multiple street light circuits are in use, but these constitute a relatively small percentage.

If electric power is to be rationed, it would seem desirable to put at the top of the list, series street lighting ahead of all other classes of usage.

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Editor's note: Under wartime shortages of critical materials, power loss and voltage regulation commonly are condoned to conserve materials.

NEW BOOKS • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

These and thousands of other technical books may be borrowed from the library by mail by AIEE members.

All inquiries related to purchase of all books reviewed in these columns should be addressed to the publisher of the book in question.

Report Writing. By C. G. Gaum, H. F. Graves, and L. S. S. Hoffman. Revised edition. Prentice-Hall, New York, 1942. 332 pages, diagrams, etc., 9$^1/_2$ by 6 inches, cloth, $2.75.

A presentation of certain principles of composition and rhetoric pertaining to the special field of the report, intended for use as a college text and for independent study. No fundamental changes have been made in the new edition, but the illustrative material, specimen outlines, and reports have been replaced by recent items; the rules for abbreviations have been changed to standard ones; and a section on letters of application has been added.

What the Citizen Should Know About Civilian Defense. By W. D. Binger and H. H. Railey. W. W. Norton and Company, New York, 1942. 183 pages, diagrams, etc., 8$^1/_2$ by 5$^1/_2$ inches, cloth, $2.50.

This book presents the advice of an experienced civil engineer and a writer upon military affairs as to proper methods of dealing with the civil problems arising out of enemy air action. The various types of bombs are described, and instructions as to protection against them given. Construction of shelters, preparation for blackouts, fire control, and gas are discussed.

Introduction to Control Engineering. By E. S. Smith. Apply to author, 114–57 176th Street, St. Albans, N. Y., 1942. Paged in sections, diagrams, etc., 11 by 8 inches, paper, including separate pamphlet of figures, $2.

These notes represent lectures on control and its applications in the process industries given by the author for an engineering, science, management, and defense-training course at Pratt Institute. The book is intended for those actively working with industrial measuring and controlling instruments and is intended as an introduction to the basic principles that underlie the solution of specific problems.

Analytic Geometry. By C. H. Lehmann. John Wiley and Sons, New York, 1942. 425 pages, diagrams, etc., 9 by 6 inches, cloth, $3.75.

A textbook for a first course in plane and solid analytic geometry. Special features are the completeness of the investigations of each topic, the construction of tables summarizing closely related results, a fuller treatment of solid analytic geometry than is usual in elementary texts, and the large number of exercises included.

The Lineman's Handbook. By E. B. Kurtz. Second edition. McGraw-Hill Book Company, New York and London, 1942. 650 pages, illustrations, etc., 7$^1/_2$ by 5 inches, $4.

A presentation of procedure and methods of line construction, accompanied by an introductory explanation of electrical principles and electric systems. The new edition has been thoroughly revised, and new chapters have been added on rural lines, tower-line erection, pole-top resuscitation, safety and rural-line operation, and maintenance.

Industrial Camouflage Manual. By K. F. Wittmann. Reinhold Publishing Corporation, New York, 1942. 128 pages, illustrations, etc., 11 by 8$^1/_2$ inches, paper, $4.

Presents experiments and experiences developed in the classrooms and camouflage laboratory of Pratt Institute. The presentation is largely by drawings and photographs. Principles, methods, and materials are described and demonstrated on models and by actual installations.

Your Career in Engineering. By N. V. Carlisle. E. P. Dutton and Company, New York, 1942. 253 pages, illustrations, etc., 8$^1/_2$ by 5$^1/_2$ inches, cloth, $2.50.

The aim of this book is to give young readers aid in choosing a vocation. The author describes the major divisions of engineering and some of the important special fields, telling what each accomplishes, how it works, and the opportunity it affords. Advice as to education and training is also included.

Principles of Radio. By K. Henney. Fourth edition. John Wiley and Sons, New York; Chapman and Hall, London, 1942. 549 pages, illustrations, etc., 8 by 5 inches, cloth, $3.50.

Aims to present the principles of radio in a form adapted to students with little electrical or mathematical background. The book is intended primarily for trade schools and for self-instruction. This edition has been revised and brought up to date.

Calculus for Practical Engineers. By A. Cibulka. Distributors, Hemphill's Book Store, Austin, Texas, 1942. 100 pages, diagrams, etc., 12 by 9 inches, paper, $3.

A concise presentation of the fundamentals of differential and integral calculus, illustrated by numerous practical examples.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Service Equipment Standards. National Electrical Manufacturers Association, New York, N. Y., 1942. 18 pages, 30 cents.

Learning the Radio Telegraph Code. American Radio Relay League, West Hartford, Conn., 1942. 34 pages, 25 cents.

The Role of the Housebuilding Industry. By Miles L. Colean. National Resources Planning Board, Washington, D. C., 1942. 29 pages.

Priorities and Industry. Division of Information, War Production Board, Washington, D. C., 1942. 83 pages.

Recommended Practice of Office Lighting. Committee on Lighting Practice, Illuminating Engineering Society, New York, N. Y., 1942. 47 pages, 25 cents.

Labor Arbitration in Wartime. The American Arbitration Association, New York, N. Y., 1942. No cost.

A Table of Common Hazardous Chemicals. The National Fire Protection Association, Boston, Mass., 1942. 20 cents.

Papers Presented at the Sixth Short Course in Coal Utilization (Engineering Experiment Station circular series No. 43). University of Illinois, Urbana, 1942. 112 pages, 50 cents.

Code of Minimum Requirements for Instruction of Welding Operators (Part A—Arc Welding of Steel $^3/_{16}$ to $^3/_4$ Inch Thick). American Welding Society, New York, N. Y., 1942. 68 pages, 50 cents.

Typical Residential Electric Bills for the Middle Atlantic States: New Jersey, New York, and Pennsylvania. Federal Power Commission, Washington, D. C., 1942. 60 pages, 25 cents.